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N71-15166

NUCLEAR ROCKET SHIELDING METHODS, MODIFICATION, UPDATING, AND INPUT DATA PREPARATION, VOLUME 5: TWO-DIMENSIONAL, DISCRETE ORDINATES TRANSPORT TECHNIQUE

R. G. SOLTESZ, ET AL

AUGUST 1970

Westinghouse Astronuclear Laboratory

WANL-PR-(LL)-034

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FINAL PROGRESS REPORT

Contract No. NAS-8-24919

Control No. DCN 1 - X - 80 - 00056

NUCLEAR ROCKET SHIELDING METHODS, MODIFICATION UPDATING, AND INPUT DATA PREPARATION

VOLUME 5

TWO-DIMENSIONAL, DISCRETE ORDINATES TRANSPORT TECHNIQUE

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NUCLEAR ROCKET SHIELDING METHODS, MODIFICATION, UPDATING, AND INPUT DATA PREPARATION

VOLUME 5

TWO-DIMENSIONAL, DISCRETE ORDINATES TRANSPORT TECHNIQUE

Prepared by:

R. G. Soltesz
R. K. Disney
J. Jedruch
S. L. Zeigler

ia

INFORMATION CATEGORY

Unclassified

J. M. Hingley 8/28/70

AUTHORIZED CLASSIFIER / DATE

ACKNOWLEDGEMENT

The authors wish to express their appreciation to F. R. Mynatt and W. W. Engle, Jr., of the Computer Technology Center of Union Carbide Corporation for their many constructive comments and assistance in developing this version of the DOT code.

FOREWORD

This report is Volume 5 of six volumes of the final report on "Nuclear Rocket Shielding Methods, Modification, Updating, and Input Data Preparation". This work was performed for the George C. Marshall Space Flight Center (MSFC), Huntsville, Alabama, under Contract No. NAS-8-24919, Control No. DCN 1-X-80-00056. The technical monitor of this contract was Mr. Henry E. Stern, Deputy Manager of the Nuclear and Plasma Physics Division of the Space Sciences Laboratory, MSFC. A description of DOT-IIW, DOQ, ADOQ, and MAP codes is presented in this volume.

In summary, the six volumes of the final report are as follows:

Volume 1: "Synopsis of Methods and Results of Analyses" - A summary of the work performed under this contract,

Volume 2: "Compilation of Neutron and Photon Cross Section Data" - A description of the six Master Libraries of neutron and photon, cross section data,

Volume 3: "Cross Section Generation and Data Processing Techniques" - A description of the GAMLEG-W, APPROPOS, NAGS, and SATURN codes,

Volume 4: "One-Dimensional, Discrete Ordinates Transport Technique" - A description of the ANISN-W code,

Volume 5: "Two-Dimensional, Discrete Ordinates Transport Techniques" - A description of DOT-IIW, DOQ, ADOQ, and MAP codes, and

Volume 6: "Point Kernel Techniques" - A description of the KAP-VI and SCAP codes.

ABSTRACT

The WANL version of the DOT computer code for solving the two-dimensional, energy dependent, linear Boltzmann transport equation with general anisotropic scattering, and the MAP computer code for solving for the angular, spatial, and energy dependent flux external to a nuclear system are described. The major improvements of the DOT-IIW code over the DOT code are the inclusion of acceleration techniques on the group flux solution, improved convergence logic, asymmetric quadrature capability, and improved tape operations. Detailed user information involving problem setup, running time, quadrature data, and mesh spacing requirements is described for both codes. In addition, requirements for eigenvalue, fixed volume distributed source, boundary source, and search calculations are given for the DOT-IIW code. Typical problem setup information is supplied for both codes as well as a description of the printed output. A sample problem card input and printout are included for each code. The Appendix describes the DOQ and ADOQ quadrature coefficient calculation codes.

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1.0 INTRODUCTION

This report is Volume 5 of six volumes of the final report on "Nuclear Rocket Shielding Methods, Modification, Updating, and Input Data Preparation." Presented in this volume is a description of the DOT-IIW, two-dimensional, discrete ordinates transport code and the MAP, radiation transport code.

The DOT-IIW and MAP codes are an integral part of both the preliminary or parametric and the detailed design radiation analysis methods provided for the Marshall Space Flight Center (MSFC) under this contract and the previous contractual work (NAS-8-20414). A simplified, schematic diagram of each method is shown in Figures 1-1 and 1-2. Both methods are fully described in Volume 1 of this report.

In the preliminary or parametric design method (Figure 1-1), the APPROPOS code (Volume 3) is used to prepare neutron and photon cross sections and other basic data for use in the transport and data processing codes. These cross sections are input to the ANISN-W code (Volume 4). The ANISN-W code computes one-dimensional neutron and photon fluxes in the reactor geometry. From the netron and photon fluxes, neutron and photon energy sources and distributions or heat generation rates are obtained using the NAGS data processing code (Volume 3). These sources and distributions are used as input to the KAP-VI point kernel code (Volume 6). The KAP-VI code provides gamma ray and fast neutron radiation levels at locations external to the reactor. Radiation sources, heat generation rates, and radiation environment, both internal and external to the reactor as well as shield effectiveness can be computed using the preliminary or parametric design method.

In the detailed design method (Figure 1-2), the neutron and photon cross sections prepared by the APPROPOS code (Volume 3) are used as input data to the DOT-IIW, two-dimensional, discrete ordinates transport code. The DOT-IIW code (Volume 5) computes the two-dimensional neutron and photon fluxes throughout the reactor geometry. The NAGS data processing code (Volume 3) processes these fluxes and calculates neutron and photon

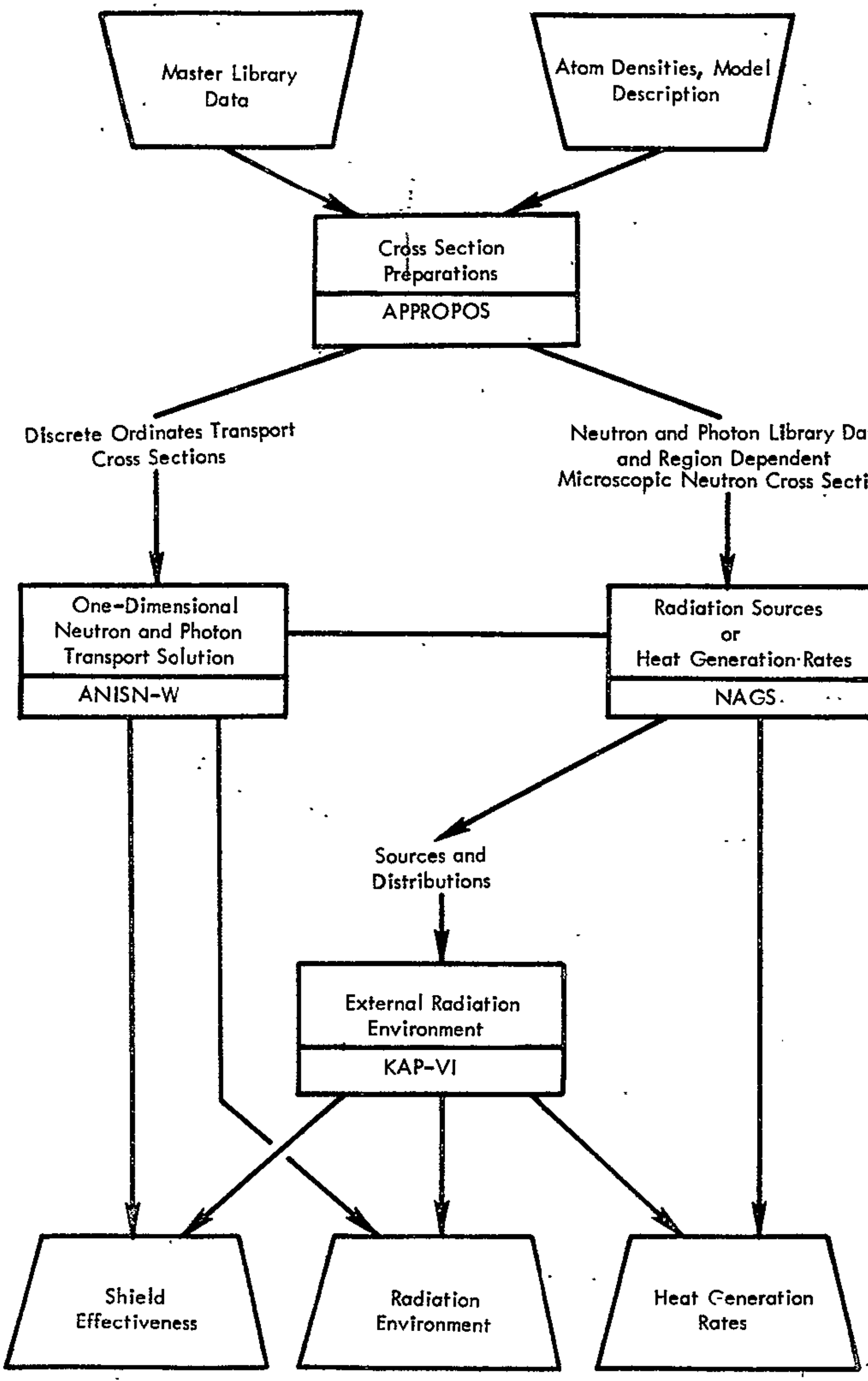

Figure 1-1. Flow Chart for Preliminary or Parametric Radiation Analysis

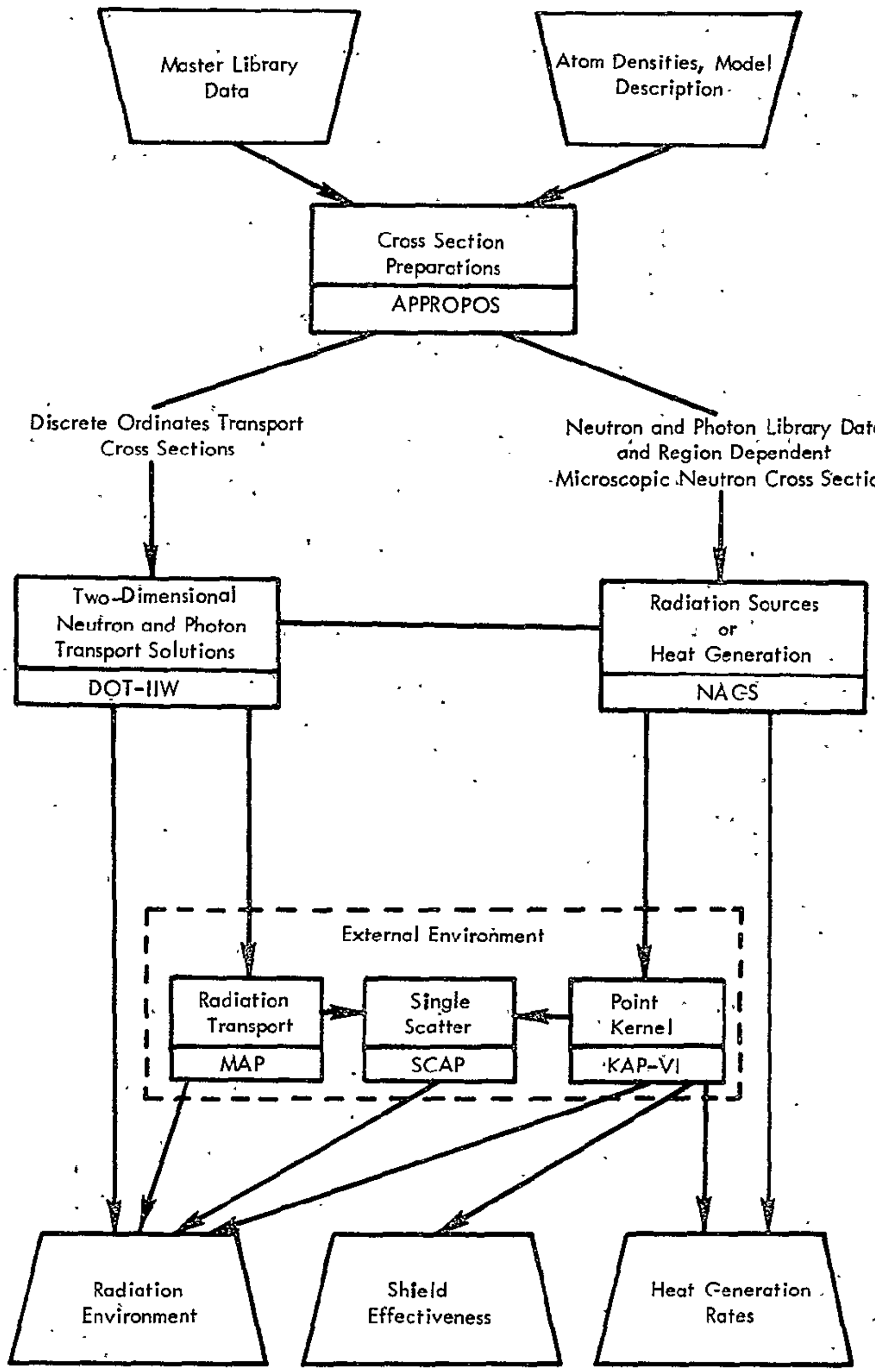

Figure 1-2. Flow Chart for Detailed Radiation Analysis

energy desposition and neutron and photon energy sources and distributions within the reactor system. These sources and distributions are used as input to the KAP-VI point kernel code (Volume 6). The KAP-VI code provides gamma ray and fast neutron radiation levels at locations external to the reactor. In addition, the surface leakage fluxes from the DOT-IIW problem geometry are used as input to the MAP radiation transport code (Volume 5). The MAP code computes the radiation environment at selected surfaces or points external to the DOT-IIW geometry and includes provision for last-flight transport using optional point kernel techniques. The SCAP single- or albedo-scatter code (Volume 6) is used to compute external radiation environment using, as source input data, the output from either the KAP-VI or the MAP codes. Radiation sources, heat generation rates, and radiation environment, both internal and external to the reactor as well as shield effectiveness can be computed using the detailed design method.

The SATURN (Volume 3), DOQ (Volume 5), and ADOQ (Volume 5) codes are additional data preparation and handling codes. These codes are provided as convenient tools for manipulating large quantities of data or providing selected input data.

In the analysis of nuclear systems, a two-dimensional, transport theory technique serves as the basis for many different types of calculations such as criticality, radiation environment,shield effectiveness, and flux attenuation. The need for a flexible, yet efficient technique to facilitate these calculations is obvious. For this reason, the DOT-IIW and MAP codes were developed.

The DOT-IIW code is described in Section 2.0 of this report; the MAP code is described in Section 3.0. Both of these codes require discrete ordinates quadrature coefficients (direction cosines and weights) generated by the DOQ (symmetric) and the ADOQ (asymmetric) codes. Appendixes A and B describe the DOQ and ADOQ codes, respectively.

2.0 DOT-IIW CODE

A reliable technique for predicting the transport of neutrons or photons through matter is a basis for a wide variety of calculations in nuclear engineering. Reactor design and analysis, shielding design and analysis, experiment analysis as well as other interests all share this common need. The method of discrete ordinates or Carlson's S_n method is one such technique for approximating the solution of the energy dependent, linear, Boltzmann transport equation with anisotropic scattering. In fact, as the approximation of the space, angle, and energy mesh approaches differential size, the solution of the Boltzmann equation approaches exactness.

The discrete ordinates technique has been implemented in the DOT-IIW code. Discrete Ordinates Transport DOT[1] solves the two dimensional, Boltzmann transport equation with general anisotropic scattering for x, y; r, z; and r, θ geometries by using a diamond difference solution technique.[2, 3] DOT solves forward or adjoint, homogeneous or inhomogeneous problems. The inhomogeneous problems may have a fixed volume distributed source or a specified angular dependent boundary source at the right or top boundaries; fissions may be included for a subcritical system. Vacuum, reflective, periodic, white, or albedo boundary conditions may be specified. Time absorption calculations, concentration searches, or zone thickness searches are also solved. Cross sections may be input from a library tape and/or from cards. Asymmetric or symmetric quadrature calculations may be performed. The code includes a choice of Gaussian Iteration, Successive Overrelaxation, Space Point Scaling, or Chebyshev Acceleration to achieve a flux solution on inner iterations.

The version of the program described in this report has been altered from the original version because of the following: (1) to be consistent with the nuclear and radiation analysis methods used at MSFC, and (2) to incorporate state-of-the-art features of the current DOT-II code released by RSIC (with the exception of a polynomial source option). A number of improvements in the convergence logic and other techniques in the DOT-II code have been included in this version of the code.

DOT-IIW is a complete code written in standard, USASI FORTRAN-IV. The code utilizes variable dimensioning to allow efficient core data storage allocation, consequently eliminating the necessity for recompilation for different size problems. This version of the code is operational on the UNIVAC-1108 computer using the EXEC-8 Monitor System, seven tape or disk devices, and input and output disks.

The program described is the latest WANL production version of the DOT code. This version is derived from the original IBM 7094 version of the DOT code as released by F. R. Mynatt, R. Rodgers, and W. W. Engle, Jr., of the Computer Technology Center of Union Carbide Corporation, Nuclear Division, Oak Ridge, Tennessee. Subsequent coding to include additional capabilities (described later) to provide a code with similar capabilities to the DOT-II code released by Mynatt, et al., has been performed by the authors.

2.1 COMPUTER CODE SYNOPSIS

1. Name: DOT-IIW[1].

2. Computer: The code is designed for the UNIVAC-1108 computer.

3. Nature of Physical Problem Solved: DOT-IIW solves the two-dimensional, energy dependent, linear Boltzmann transport equation with general anisotropic scattering for x, y; r, z; and r, θ geometries. DOT solves forward or adjoint, homogeneous or inhomogeneous problems. The inhomogeneous problems may have a fixed volume distributed source, or a specified angular dependent boundary source at the right or top boundaries; fissions may be included for a subcritical system. Vacuum, reflective, periodic, white, or albedo boundary conditions may be specified. Time absorption calculations, concentration searches, or zone thickness searches are also solved. Cross sections may be input from a library tape and/or from cards. Asymmetric or symmetric quadrature calculations may be performed. The code includes a choice of Gaussian Iteration, Successive Overrelaxation, Space Point Scaling, or Chebyshev Acceleration to achieve a flux solution on inner iterations.

4. Method of Solution: The discrete ordinates or Carlson's S_n method using a diamond difference solution technique is employed.[2] The method is applicable to both neutron and gamma-ray transport problems. The solution in the code will approach the exact solution of the Boltzmann equation with increasing orders of approximation as the space, angle, and energy mesh approaches differential size.

5. Restrictions on the Complexity of the Problem: The DOT-IIW computer code utilizes variable dimensioning to facilitate efficient core data storage allocation. Because of the variable dimensioning technique on any given data array, no size restriction is imposed; only a size restriction on the length of the sum of all arrays is imposed. The amount of core data storage for a given problem may be exactly computed as indicated in the documentation.

6. Typical Running Time: The DOT-IIW code computes approximately 4500 angular fluxes per second.

7. Unusual Features of the Program: The code employs a general anisotropic scattering capability, variable dimensioning, and the concentration of the bulk of the computations in one subroutine.

8. Related and Auxiliary Programs: Cross sections may be supplied by the APPROPOS(3) or GAMLEG-W(3) codes. Fixed distributed neutron or photon sources as well as energy deposition may be provided using the MAP(1) code.

9. Status: The code is in production use at MSFC. Users at MSFC load the code from a disk or tape with control cards followed by the user's input data.

10. References:

1. R. K. Disney, R. G. Soltesz, J. Jedruch, and S. L. Zeigler, WANL-PR(LL)-034, Volume 5, "Two-Dimensional, Discrete Ordinates Transport Techniques," August 1970.
2. F. R. Mynatt, F. J. Muckenthaler, and P. N. Stevens, CTC-INF-952, "Development of Two-Dimensional Discrete Ordinates Transport Theory for Radiation Shielding," August 1970.
3. R. K. Disney, R. G. Soltesz, and S. L. Zeigler, WANL-PR(LL)-034, Volume 3, "Cross Section Generation and Data Processing Techniques," August 1970.

11. Machine Requirements: The DOT-IIW code is in production at MSFC on the UNIVAC-1108 with 65K core storage locations. The source program requires 14K decimal locations; the remaining locations are used for problem data storage. Up to eight tape or disk devices are required in addition to input and output disks.

12. Programming Language Used: The code is written in standard, USASI FORTRAN-IV.

13. Operating System or Monitor Under Which Program is Executed: The DOT-IIW code is operational under the EXEC-8 Monitor System.

14. Other Programming or Operating Information or Restrictions: None.

15. Name and Establishment of Authors:

R. G. Soltesz and R. K. Disney
Westinghouse Astronuclear Laboratory
P. O. Box 10864
Pittsburgh, Pa. 15236

2.2 INPUT DATA DESCRIPTION

2.2.1 Input Format

The input data for the DOT-IIW code are divided into the following nine data sets:

1) Overall problem storage allocation, tape assignments, and boundary source input tape parameters
2) Overall problem title and parameters
3) Cross section data
4) Flux guess data
5) Fixed distributed source data
6) Fixed boundary source data
7) Angular quadrature (direction cosines: μ, η) data
8) Angular quadrature (weights: w) data
9) Remainder of data

The first data set is entered on a single formatted card which is the first physical card of each problem deck. The second data set consists of the title card and nine cards of integer and real (floating point) data intermixed on formatted cards in data fields of 12 columns each. This set of data is always required as input to a DOT-IIW problem and all input data must be entered in the correct field of each card since a fixed, FORTRAN format is used to read all cards.

All remaining data sets (3 through 9) of a DOT-IIW problem input are written in one of three FORTRAN type format capabilities. The integer data arrays (denoted by a dollar sign) must always be input in the standard DOT-IIW format capability which consists of 6 fields of 12 columns in each field. Each field in the standard format is subdivided into three subfields as shown in Figure 2-1. Integer data must be entered as right adjusted* in the third subfield of each data field. Real data (denoted by a *, U, or V) may be entered in the standard DOT-IIW or one of two non-standard, FORTRAN format capabilities.

The non-standard WANL DOT input formats which are shown in Figure 2-1 are included for the user's convenience and can only be used for any real (floating point) data

* "Right adjusted" means that the last significant digit of a number is at the extreme right of a field.

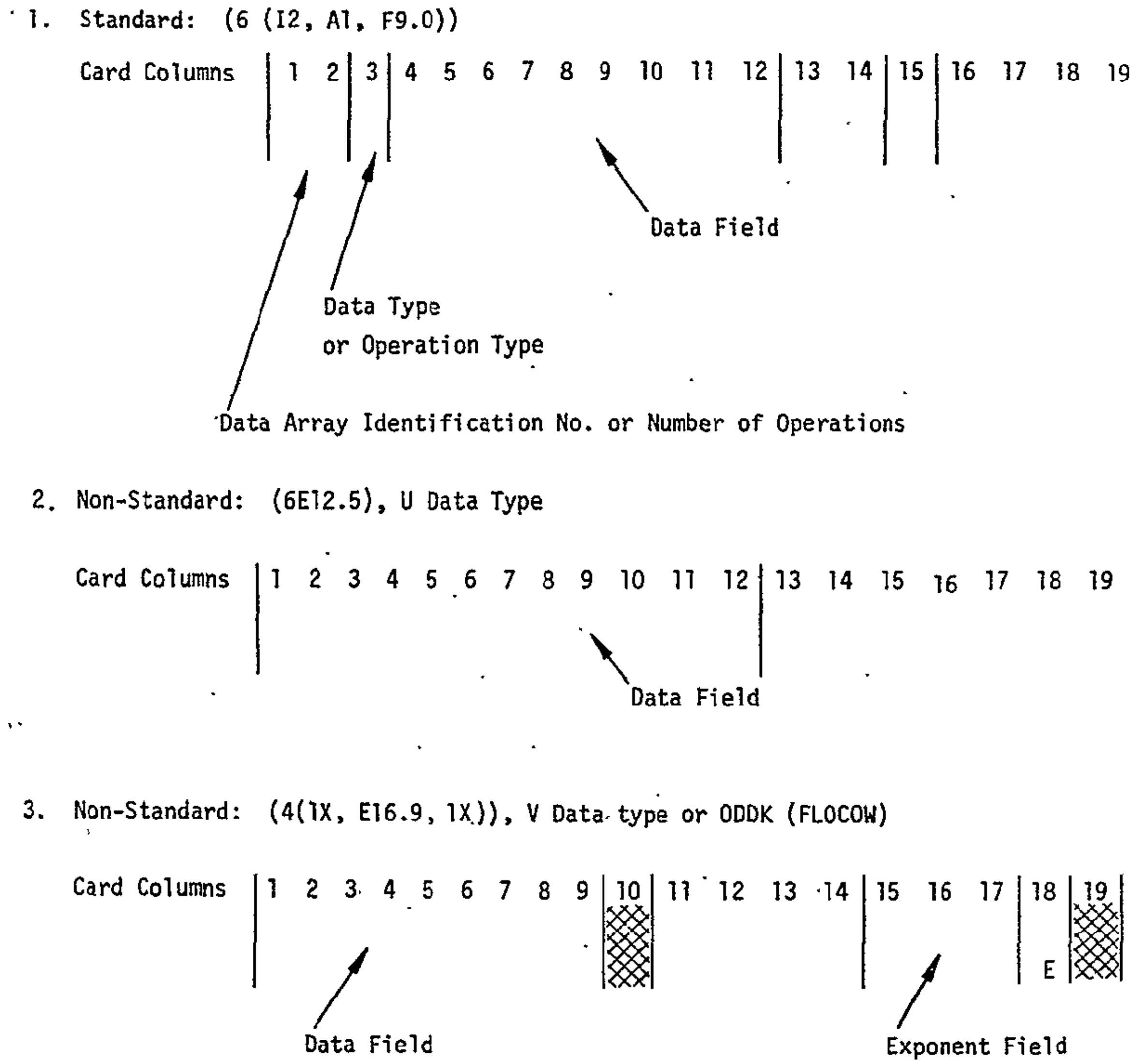

Figure 2-1. DOT-IIW Input Formats

array. These non-standard formats cannot include any operation type (fill, skip, interpolate, repeat, etc.), but can include blank fields on a card that cause the input routine to ignore the rest of the card; e.g., if the punched cross section data for a material includes 117 entries (9 groups by 13 tables), the set would be 19 full cards and a final card of three entries using the U format. DOT-IIW, using this non-standard capability, would skip the last three fields and commence reading at the first data field of the next card.

In the standard DOT-IIW format, the second subfield may include one of the data type or operation type code letters. The following characters may be entered: $, *, U, V, R, I, T, S, F, A, +, -, Z, E, Q, N, M, W, or X.

$ indicates the beginning of an integer (fixed point) array. The first subfield identifies the data array.

* indicates the beginning of a real (floating point) array in standard format. The first subfield identifies the array.

U indicates the beginning of a real (floating point) array in the non-standard format 6E12.5 and the data array beginning on the next physical card. The first subfield identifies the array.

V indicates the beginning of a real (floating point) array in the non-standard ODD-K format 4 (1X, E16.9, 1X). The first subfield identifies the array beginning on the next physical card.

R indicates that the data contained in the third subfield are to be entered R times in succession. The first subfield defines the number of total successive entries or Repeats (e.g., a 16R 1.0 enters 16 1.0's).

I indicates linear Interpolation between the data in the associated third subfield and the following third subfield. The first subfield defines the number of interpolations between the two data entries (e.g., 4I 0.0, 10.0 enters 0.0, 2.0, 4.0, 6.0, 8.0, 10.0).

T indicates Termination of data reading for a particular subset of data. No further data reading for a subset of data is attempted and the program proceeds to the next subset and the next physical data card.

S indicates Skip. The first subfield defines the number of entries to be skipped. The third subfield may contain the first entry following the skips (e.g. 15 S 1 enters a 1 in the 16th word of an array).

F indicates that the remainder of the present array is to be Filled with the data entry in the third subfield. Any entry in the first subfield is ignored (e.g., F 1.0 will enter a 1.0 for all entries in an array).

A indicates Address modification. The next non-blank data entry is entered in the Nth location of the present array where N is an integer entry in the third subfield associated with the A. Any entry in the first subfield is ignored.

+ or - indicates exponentiation. The data entry in the third subfield is multiplied by $10 \pm N$ where N is the entry in the first subfield. This option allows more significant digits if necessary.

Z indicates the entry of Zeros. The integer entry in the first plus the third subfield indicates the number of successive zeros to be entered. (e.g., 10Z enters 10 zeros, Z 20 enters 20 zeros, and 10Z 20 enters 30 zeros).

E indicates End array. This option skips to the end of an array without the need for specifying the number of skips.

Q indicates sequence repeat. The integer entry in the first plus the third subfield indicates the number of previous entries to be repeated.

N indicates inverted sequence repeat. This option is similar to the Q option except that the previous entries are repeated in reverse order, (e.g., 0, 2, 4, 2N enters 0, 2, 4, 4, 2).

M indicates inverted sequence repeat except that the signs of previous entries are reversed when they are repeated.

W indicates the array identified by the first subfield will be read according to the format on the following card.

X indicates the array identified by the first subfield will be read according to the last variable format read in. For example,

3W	Card 1 (remainder of card must be blank)
(7E 10.3)	Card 2 (contains format only)
3X	Card 3 (remainder of card must be blank)
	Cards 4 through N (contain the data according to the specified format. No blank fields are allowed)

Integer data in the third subfield must be right adjusted. Floating point data may be written with or without an exponent and with or without a decimal point. If the decimal point is not included, it is assumed to be immediately to the left of the exponent field within the nine-column subfield. If there is no exponent, the decimal point is assumed to be at the extreme right of the nine column subfield.

The following restrictions must be observed when writing input data for the DOT-IIW code:

1) Floating point zeros must be written as 0. or 0.0; A.0 or -0.0 in either the standard or non-standard format is not acceptable.

2) Blanks are ignored and the reading of data commences on the next physical card for the non-standard format and on the next field after the blank field for the standard formats.

3) If an I is specified in any data field, the third subfield of that field and the following third subfield of the next field cannot be blank. In addition, the second subfield of the field following a field containing an I cannot contain an A.

4) If the third subfield of a data field containing a $ or a * contains an integer, N, the next data entry is assumed to be the (N + 1) th member of the array. Normally this third subfield is blank and is interpreted as zero.

2.2.2 Input Data Instructions

This section describes the problem input data for the DOT-IIW code. Section 2.3 presents a more detailed description of the data presented here. The quantity in slashes represents the array dimension, or the number of pieces of data required, and the expression in braces is the condition requiring that array or set of arrays. Arrays or sets of arrays with the corresponding terminate (T) card which are not required should not be entered. If no condition is specified, the array is required. Note that a T card must follow the data entered in data sets 3 through 9; no T card is entered after data sets 1 and 2.

DATA SET 1 - OVERALL PROBLEM STORAGE ALLOCATION, TAPE ASSIGNMENTS, AND INPUT TAPE PARAMETERS

Card	Format	Column	Variable	Description
1	I10	1-10	ISIZE*	The maximum number of locations available for DOT-IIW data (e.g., ISIZE = 51000_{10} on the UNIVAC-1108, EXEC-8 computer with a 65K core memory storage available).
	I4	11-14	NINP	Input data tape drive. Always set NINP = 5
	I4	15-18	NOUT	Output data tape drive. Always set NOUT = 6
	I4	19-22	NCR1	Scratch tape drive. Always set NCR1 = 1
	I4	23-26	NSCRAT	Scratch tape drive. Always set NSCRAT = 2
	I4	27-30	NBSO	Distributed source tape. Always set NBSO = 8. If a non-zero normalization factor (S01) for a fixed distributed source problem is input, the code will normalize the input source data and place it on a scratch tape drive (1, 2, or 3).
	I4	31-34	NFLUX1	Scratch tape drive. Always set NFLUX1 = 3
	I4	35-38	NAFT	Angular flux output tape drive. Always set NAFT = 4
	I4	39-42	IBXS	Boundary source input option. 0/1, no boundary source data or boundary source data from cards/boundary source entered from tape drive 9. If IBXS = 1, mount boundary source tape (in format of DOT-IIW angular flux output tape) on tape drive 9.
	I4	43-46	IMOLD	Number of radial mesh intervals in the input boundary source data tape on tape drive 9. IMOLD must be greater than or equal to the number of radial mesh intervals, IM, in the current DOT problem. [If IBXS = 0/IMOLD = 0]

* The maximum value of ISIZE is determined by the maximum size of BLANK COMMON set at code compile time.

Card	Format	Column	Variable	Description
	I4	47-50	JMOLD	Number of axial mesh intervals in the input boundary source data tape on tape 9. JMOLD must be equal to the number of axial mesh intervals used to describe the boundary source. If a previous DOT-IIW problem was used to generate this data tape, two techniques in DOT-IIW exist to generate this tape. If the DOT-IIW input quantity, A11 = 0, then JMOLD must equal the number of axial mesh intervals, JM, in the previous DOT-IIW problem. If A11 > 0, then JMOLD must equal 3.
	I4	51-54	JMLEV	Specific axial interval number at which boundary source data will be obtained from boundary source data tape on tape 9. If a previous DOT-IIW problem was used to generate this data tape, the following options exist: If A11 = 0 in the previous DOT-IIW problem, then JMLEV can be any axial interval in the previous DOT-IIW problem. If A11 ≠ 0, then JMLEV can be axial intervals 1, 2, or 3 which correspond to axial intervals A11 + 1, A11, or A11-1 from the previous DOT-IIW problem. If a MAP problem has been used to generate a boundary source tape, then JMLEV must be equal to 2 or 3 depending upon the DOT-IIW problem surface considered as a source and defined by the input quantity, IDIR. [If IBXS = 0: then JMLEV = 0]
	I4	55-58	IDIR	Direction of boundary source data from previous DOT-IIW or source surface from previous MAP problem. If tape 9 is from a previous DOT-IIW problem, then the downward directed or upward directed angular flux at an axial mesh interval can be input as a top boundary source as follows: [If IDIR = 0/1 - Upward/Downward]

Card	Format	Column	Variable	Description
				If tape 9 is obtained from a MAP problem, then the following options exist:
				[If JMLEV = 3: IDIR = 0/1 - total visible surface/top or bottom visible surface]
				[If JMLEV = 2: IDIR = 0 - side visible surface]
	I4	59-62	NA	Starting radial mesh interval number in IMOLD at which the boundary source angular flux data from tape 9 is desired for DOT-IIW problem [NC = 0 if IBXS = 0]
	I4	63-66	NC	Final interval number in IMOLD at which the angular flux boundary source data from tape 9 is desired for DOT-IIW problem. [NC = 0 if IBXS = 0]
				If NA and NC are both zero, no selective boundary source is used; i.e., the boundary source data is used for all IMOLD intervals. If NA and NC are greater than zero, the code only uses data from NA to NC, inclusive. All other radial interval data are set to zero.

DATA SET 2 - OVERALL PROBLEM TITLE AND INPUT PARAMETERS

Card	Format	Column	Variable	Description
2	12A6	1-72	TITLE	Problem descriptive title card
3	I12	1-12	A01	Problem identification number
	I12	13-24	A02	0 - forward calculation 1 - adjoint calculation
	I12	25-36	A03	Maximum order of scattering found in any zone (0/1/2 . . .; P_0, P_1, P_2 . . .)
	I12	37-48	A04	Number of space angles (discrete directions) in calculation (6/16/30/48. . .; $S_2/S_4/S_6/S_8$. . .)
				See Section 2.2.4 for additional information

Card	Format	Column	Variable	Description
	I12	49-60	IGE	Geometry Parameter 0 - x, y geometry 1 - r, z geometry 2 - r, θ geometry
	I12	61-72	IZM	Number of zones or regions in the problem geometry (9$)
4	I12	1-12	IM	Number of x or radial mesh intervals in the problem geometry (4*)
	I12	13-24	JM	Number of y, z, or θ mesh intervals in the problem geometry (2*)
	I12	25-36	I04	Type of calculation to be performed 0 - Q-fixed volume distributed source calculation (inhomogeneous calculation) 1 - k-calculation (eigenvalue (homogeneous) calculation) 2 - α - time absorption calcualtion 3 - C - concentration search calculation 4 - δ - zone thickness search calculation 5 - BQ - fixed boundary source calculation (inhomogeneous calculation)
	E12.5	37-48	EV	Eigenvalue guess for search calculations (I04 = 2, 3, and 4) See detailed notes for explanation. Set EV = 0.0 if I04 = 0, 1, or 5.
	E12.5	49-60	EVM	Eigenvalue guess modifier used in search calculations. If I04 = 2, 3, or 4, the second guess of the eigenvalue is set equal to EV+EVM where the sign of the quantity, EVM, is taken as positive, if the first eigenvalue is greater than 1.0. Set EVM = 0.0, if I04 = 0, 1, or 5.

Card	Format	Column	Variable	Description
	E12.5	61-72	EPS	Overall problem convergence criteria. This quantity is used to test: 1) the convergence in eigenvalue or search calculations, 2) the convergence of reflected or periodic boundary conditions and, if applicable, 3) the integral convergence of the flux solution in each group. The value of EPS is strongly dependent on the type of calculation being performed and the convergence criteria placed on flux and/or upscatter by the input quantities of pointwise flux convergence criteria G06, and upscatter convergence criteria, A14. Experience has shown that the value of EPS should be equal to or greater than G06 and equal to or less than A14.
5	I12	1-12	B01	Left boundary condition 0 - vacuum (no reflection 1 - reflection (dØ/dX = 0) 2 - periodic (angular flux leaving boundary re-enters at the opposite boundary -- left-right or top-bottom -- in the same angle
	I12	13-24	B02	Right boundary condition 0, 1, or 2 -- same as B01 conditions described above. 3 - white (isotropic re-entrant angular flux)-- the integral of the angular flux leaving the boundary is returned as an isotropic angular flux in all incoming discrete angles. 4 - boundary source (input angular dependent data from cards or tape. If IBXS = 0, I04 = 5 and B02 = 4, then the boundary source data 18* or 18U is required input. The present DOT-IIW will not allow right boundary source input from tape. 5 - albedo (same condition as the white boundary condition B02 = 3 except that the isotropic re-entrant angular

Card	Format	Column	Variable	Description
				flux at the boundary is multiplied by the position and group dependent albedo input data as entered in the 25* or 25U array).
	I12	25-36	B03	Top boundary condition 0, 1, 2, 3 - Same as B02 condition except that if IBXS = 1, I04 = 5, and B03 = 4, then the boundary source data are entered on tape 9. If IBXS = 0, I04 = 5, and B02 = 4, then the boundary source data 18* or 18U are required input. 5 - Same as B02 condition except that the position and group dependent albedo input data are entered in the 26* or 26U array.
	I12	37-48	B04	Bottom boundary condition 0, 1, 2, 3 - Same as B02 conditions described above 5 - Same as B02 conditions except that the position and group dependent albedo input data are entered in the 27* or 27U array.
	I12	49-60	M07	Flux input option trigger 0 - Enter flux guess as a single set of values in a 3* or 3U array. A total of IGM group values is required input with a uniform distribution in space and the IGM values provide an input energy (group) dependence as follows: $N_{ijg} = A_g$ 1 - Enter flux guess as IGM sets of values in successive sets of 3* or 3U arrays. A total of IGM sets of values are terminate (T) cards. Each set of data are IM*JM values describing the flux guess for each group of the IGM groups to be solved for as follows: $N_{ijg} = A_{ijg}$

Card	Format	Column	Variable	Description
				2 - Enter flux guess as two sets of values in successive 3* or 3U arrays with terminate (T) cards. The first 3* or 3U array is IGM values of group dependent data and the second set of 3* or 3U arrays is IM*JM values of space dependent data to provide the flux guess as follows: $N_{ijg} = A_g B_{ij}$ 3 - Enter flux guess as three sets of values in successive 3* or 3U arrays with terminate (T) cards. The first 3* or 3U array is IGM values of group dependent data; the second set is IM values of space dependent (X, R, or R) data; and the third set is JM values of space dependent (Y, Z, or θ) data to provide the flux guess as follows: $N_{ijg} = A_g B_i C_j$ 4 - Enter flux guess as two sets of values for each group of the IGM groups in successive 3* or 3U arrays with terminate (T) cards. The first 3* or 3U array for each group is IM values of the space dependent (X, R, or R) data, and the second 3* or 3U array for each group is JM values of the space dependent (Y, Z, or θ) data. The flux guess is constructed as follows: $N_{ijg} = A_{ig} B_{jg}$ 5 - Enter flux guess as group and space dependent data from tape 12. No 3* or 3U arrays and corresponding terminate (T) cards are required.
	I12	61-72	MODE	Flux calculation option 0 - Use linear flux calculation mode only and do not recompute angular flux if solution is negative (Operational and recommended for specific problems) 1 - Mixed mode--use linear flux calculation mode and recompute angular flux with step function model if solution is negative. (Recommended option for normal problems)

Card	Format	Column	Variable	Description
				2 - Use step function model only (Operational but not recommended option.)
				3 - Use weighted difference flux calculation mode (Operational and recommended for specific problems.)
6	I12	1-12	MT	Total number of materials (MCR + MTP + Mixtures formed in cross section mixing table)
	I12	13-24	M01	Cross section mixing table length (10$, 11$, 12*)
	I12	25-36	MCR	Number of cross section sets to be read from cards (data entered in 14* or 14U array.)
	I12	37-48	MTP	Number of cross section sets to be read from input tape--(identification numbers of each set are entered in the 13$ array). NOTE: 1. Cross section tape is mounted on tape unit 14 2. Cross sections from cards are read in before those from tape. 3. Each set of cross sections whether from cards, tape, or formed in the mixing table is assigned a unique number less than or equal to the total number of sets, MT. If MCR and MTP are both equal to zero, a specially prepared group independent tape (IGM records of MT*ITL data) is required input on unit NCR1. This special tape can be obtained from a previous DOT-IIW problem, or it can be generated by the SATURN code.
	I12	49-60	IZ	Number of radial zones for a zone thickness search. Enter a zero for 104 $\neq$ 4. See detailed notes in Section 2.3.4 for explanation.

Card	Format	Column	Variable	Description
	I12	61–72	JZ	Number of axial zones for a zone thickness search. Enter a zero for I04 ≠ 4. See detailed notes in Section 2.3.4 for explanation.
7	I12	1–12	S02	Type of parametric eigenvalue search 0 – not a parametric eigenvalue search (I04 = 0, 1, or 5) 1 – search on k in I04 = 3, 4 calculation 2 – search on α in I04 = 2 calculation
	E12.5	13–24	S03	Parametric eigenvalue for search. Enter as 0.0 for I04 ≠ 2, 3, or 4
	I12	25–36	IGM	Number of energy groups in the calculation
	I12	37–48	IHT	Position of $\sum_{total}$ or $\sum_{transport}$ in cross section table.
	I12	49–60	IHS	Position of $\sum_{gg}$ (within-group scatter) in cross section table.
	I12	61–72	ITL	Length of cross section table.
8	E12.5	1–12	S01	Normalization factor (If S01 = 0.0, no normalization of source data is performed)
	I12	13–24	M05	Activity calculation option (19$, 20$) 0 – no activities calculated N – compute N activities for each mesh cell
	I12	25–36	M06	Fixed volume distributed source input option 0 – Enter source guess as a single set of values in a 17* or 17U array. A total of IGM group values is required input with a uniform distribution in space and the IGM values provide an input energy (group) dependence as follows: $N_{ijg} = A_g$ 1 – Enter source guess as IGM sets of values in successive sets of 17* or 17U arrays separated by terminate (T) cards. Each set of data is IM*JM values

Card	Format	Column	Variable	Description
				describing the source guess for each group of the IGM groups to be solved for as follows: $N_{ijg} = A_{ijg}$ 2 - Enter source guess as two sets of values in successive 17* or 17U arrays with terminate (T) cards. The first 17* or 17U array is IGM values of group dependent data and the second set of 17* or 17U arrays is IM*JM values of space dependent data to provide the source guess as follows: $N_{ijg} = A_g B_{ij}$ 3 - Enter source guess as three sets of values in successive 17* or 17U arrays with terminate (T) cards. The first 17* or 17U array is IGM values of group dependent data; the the second set is IM values of space dependent (X, R, or R) data; and the third set if JM values of space dependent (Y, Z, or θ) data to provide the source guess as follows: $N_{ijg} = A_g B_i C_j$ 4 - Enter source guess as two sets of values for each group of the IGM groups in successive 17* or 17U arrays with terminate (T) cards. The first 17* or 17U array for each group is IM values of the space dependent (X, R, or R) data, and the second 17* or 17U array for each group is JM values of the space dependent (Y, Z, or θ) data. The source guess is constructed as follows: $N_{ijg} = A_{ig} B_{jg}$ 5 - Enter source guess as group and space dependent data from tape 8. No 17* or 17U arrays and corresponding terminate (T) cards are required. This tape can be generated with the NAGS data processing code.
	I12	37-48	S04	Initial maximum number of inner iterations per group. This value limits the number of inner iterations for each group on an outer iteration until eigenvalue convergence of $\|LAMBDA - 1.0\|$ is less than 10.0 times EPS. (Suggested value of S04 is equal to G07.)

Card	Format	Column	Variable	Description
	I12	49-60	D05	Outer iteration maximum The value for k and search calculations, I04 = 1, 2, 3, 4, is dependent upon complexity of problem. Suggested value for source calculations, I04 = 0 or 5, is dependent upon presence of upscatter or fissions in the problem, and angular flux output option. If no upscatter or fissions, the following input is required: If IAFT = 0 for no angular flux output, then D05 must equal 1. If IAFT $\neq$ 0 for angular flux output, then D05 must equal 0. If upscatter or fissions are present, then D05 must be greater than 1 to converge upscatter and/or fission distribution. See detailed notes in Sections 2.3.1 through 2.3.4 for explanation.
	I12	61-72	G07	Maximum number of inner iterations per group
9	E12.5	1-12	G05	Enter as 0.0
	E12.5	13-24	G06	Pointwise flux convergence criteria. Pointwise flux convergence test is not made if G06 = 0.0. If G06 is greater than 0.0, the pointwise flux convergence must be satisfied for the entire problem or for specified zones of convergence on the inner iteration calculations. (Suggested value of G06 is equal to or less than EPS for eigenvalue calculations, and equal to EPS for source calculations.)
	E12.5	25-36	LAL	Search calculation convergence criteria. If $\lvert \text{LAMBDA} - 1.0 \rvert < \text{LAL}$, DOT-IIW uses a linear search calculation and if $\lvert \text{LAMBDA} - 1.0 \rvert > \text{LAL}$, a quadratic calculation is performed. (Suggested value for search calculations, LAL = 0.01, for other calculations, LAL = 0.0)

Card	Format	Column	Variable	Description
	E12.5	37-48	LAH	Upper limit on |LAMBDA - 1.0| used in linear search. (Suggested value for search calculations, LAH = 0.05, for other calculations, LAH = 0.0)
	E12.5	49-60	POD	Parameter oscillation damper. (Suggested value for search calculations, POD = 0.75; for other calculations, POD = 0.0.)
	E12.5	61-72	EPSA	Epsilon for new parameters. (Suggested value for search calculations, POD = 0.75; for other calculations, POD = 0.0.)
10	I12	1-12	IAFT	Angular flux output trigger 0 - no angular flux output desired 1 - write binary angular flux tape 2 - print angular fluxes 3 - both 1 and 2 NOTE: 1. If IAFT = 0, then D05 must be input equal to or greater than 1 for all calculations. 2. If IAFT $\neq$ 0, then D05 must be input to 0 for source calculations if no upscatter or fissions are present in problem (e.g., photon transport), or greater than 0 if upscatter or fissions are present.
	I12	13-24	A05	Number of quadrature angles in the upward ($+\eta$) direction. The upward ($+\eta$) direction refers to the direction of increasing y, z, or θ with respect to (x, y), (r, z) or (r, θ) geometry. See details noted in Section 2.2.4 for explanation of A04, A05, A06, A07, and A08 input data.
	I12	25-36	A06	Number of quadrature angles in the downward ($-\eta$) direction.

Card	Format	Column	Variable	Description
	I12	37-48	A07	Number of quadrature initialization directions in the upward ($+\eta$) direction.
	I12	49-60	A08	Number of quadrature initialization directions in the downward ($-\eta$) direction.
	I12	61-72	A09	Inner iteration convergence acceleration option: A09 = 0, Gaussian (or normal) acceleration A09 = 1, Successive Overrelaxation A09 = 2, Space Point Scaling A09 = 3, Chebyshev acceleration
11	I12	1-12	A10	Zones of Convergence Option: 0/N where N is the number of zones to be used in convergence tests and the zone numbers are specified in the 28$ array.
	I12	13-24	A11	Axial Interval at which Angular Fluxes are desired. If A11 = 0, all intervals are obtained. If A11 $\neq$ 0, then three intervals of data are obtained centered about interval A11.
	I12	25-36	A12	Number of Neutron Energy Groups. (Not used. Set A12 = 0)
	I12	37-48	A13	0/1 = Print/Don't print cross sections.
	I12	49-60	A14	Upscatter Epsilon. If A14 is entered as zero, A14 is internally set equal to EPS. If A14 is entered as non-zero, A14 is used as the upscatter epsilon.
	I12	61-72	A15	Enter as 0

DATA SET 3: CROSS SECTION DATA

Cross Section Data {MCR $\neq$ 0 and/or MTP $\neq$ 0}

13$ Library tape ID Numbers / MTP / {MTP > 0} Cross section set ID numbers are entered for sets to be obtained from input data tape on tape unit 14. Data tape is in a format identical to the ANISN-W tape and can be generated by the SATURN, GAMLEG-W, and APPROPOS codes. ID numbers must be ordered in the sequence of data sets on tape.

14* or U Cross section data on cards are entered. /ITLxIGMxMCR/ {MCR > 0}

NOTE: 1) If MCR $\neq$ 0 and MTP $\neq$ 0, then the cross section data from cards (MCR sets) are the first MCR sets in a DOT problem and tape data are the MCR + 1 to MCR + MTP sets.

2) If MCR = 0 and MTP = 0, then all cross section data are input on tape unit NCR1. This specially prepared, group independent tape can be obtained from a previous DOT-IIW problem or from the SATURN code.

Terminate Card

DATA SET 4: INPUT FLUX DATA

Flux Data {M07 < 5}

3* or U Flux guess is entered on cards in the manner specified by the input parameter M07 on card 5 of data set 2.

NOTE: If more than one set of 3* or 3U data is required, each set is preceded by a 3* or 3U card and followed by a terminate card.

Terminate Card

DATA SET 5: INPUT FIXED DISTRIBUTED SOURCE DATA

Fixed Distributed Source Data {I04 = 0 and M06 < 5}

17* or U Fixed distributed source data are entered on cards in the manner specified by the input parameter M06 on card 8 of data set 2.

NOTE: If more than one set of 17* or 17U data is required, each set is preceded by a 17* or 17U card and followed by a terminate card.

Terminate Card

DATA SET 6: INPUT FIXED BOUNDARY SOURCE DATA

Fixed Boundary Source Data {I04 = 5 and IBXS = 0}

18* or U — Boundary source data for right and/or top boundaries of problem are entered on cards in the manner specified in Section 2.3.3.

Terminate Card

DATA SET 7: ANGULAR QUADRATURE DIRECTION COSINE DATA

Angular Quadrature Direction Cosine Data

7* or U — Angular quadrature direction cosines, μ_m and η_m / (A05 + A06) *2 values)/
Quadrature data are entered on cards with the A04 values of μ_m data preceding the A04 values of η_m data. See Section 2.2.4 for additional information.

Terminate Card

DATA SET 8: INPUT ANGULAR QUADRATURE WEIGHT DATA

Angular Quadrature Weight Data

6* or U — Angular quadrature weights, W_m/ A05 + A06 values/
Quadrature weight data are entered on cards. See Section 2.2.4 for additional information.

Terminate Card

DATA SET 9: REMAINDER OF DATA

1* or U — Fission spectrum data /IGM/

The sum of the IGM values of the 1* or U array should equal 1.0 for k_{eff} or search calculations (I04 = 1, 2, 3, 4). If I04 = 0 or 5 and fissionable materials are in regions, then the 1* or U values may be input as 0.0 to suppress calculation of new fission source distributions on outer iterations.

4* or U — X or Radial mesh line coordinates /IM + 1/
Mesh line coordinates defining the IM mesh intervals in the X or R direction.

2* or U — Y, Z, or θ mesh line coordinates /JM + 1/
Mesh line coordinates defining the JM mesh intervals in the Y, Z, or θ direction.
The dimension of the θ coordinates are input in revolutions (e.g., $\theta_i = \theta_i$ (radians)/ 6.28318 or $\theta_i = \theta_i$ (degrees)/360.0)

8$	Zone number by mesh cell /IM x JM/ Data are entered starting at the lower left mesh cell of the geometry and entered for all X or R mesh cells for the first Y, Z, or θ mesh row; all mesh cells for the second Y, Z, or θ mesh row, etc., until all mesh cells are defined. Entries in 8$ array must range from 1 to IZM.
9$	Material Number by zone /IZM/. A *negative material number* identifies the material as an anisotropic material and cross section - input or mixtures formed in DOT-IIW require that the P_ℓ (ℓ>o) cross section sets must be the m + 1, *m + 2, etc., sets following the negative material number m.* For example, if A03 = 3 and zone 6 contains the anisotropic scattering material 10, then a -10 entry is the sixth number in the 9$ *array and the material data* 11, 12, 13, *must contain the* P_1, P_2, and P_3 scattering data for material 10.
5* or U	Representative velocities by group /IGM/ Velocities must be non-zero and are required input only for a time absorption (Rossi alpha) calculation (I04 = 2). For all other calculations (I04 ≠ 2) enter velocities at 1.0s.
10$	*Mixture material numbers in mixing table /M01/* {M01>0} See Section 2.3.7 for details.
11$	Component material numbers of mixtures in mixing table /M01/ {M01 > 0} See Section 2.3.7 for details.
12* or U	Atom densities of component materials in mixing table /M01/ {M01 > 0} See Section 2.3.7 for details.
19$	Material numbers for activity calculation /M05/ {M05 > 0} A positive material number will cause the activity calculation for only those mesh cells in which the material appears in the 9$ array. If the material is negative, then the activity calculation is performed for all mesh cells. See Section 2.3.7 for details.
20$	Cross section table position for activity calculation /M05/ {M05 > 0} A cross section table position is required for each material number in the 19$ array. See Section 2.3.7 for details.
21$	X or Radial search zone numbers /IM/ {I04 = 4}
22* or U	X or R search zone modifiers /IZ/ {I04 = 4}
23$	Y, Z, or θ search zone numbers /JM/ {I04 = 4}

24* or U — Y, Z, or θ search zone modifiers /JZ/ {I04 = 4}

25* or U — Right boundary albedo data /JMxIGM/ {B02 = 5}

Data are entered in order of increasing Y, Z, or θ for group 1. This sequence is repeated for IGM groups.

26* or U — Top boundary albedo data /IMxIGM/ {B03 = 5}

Data are entered in order of increasing X, R for group 1. This sequence is repeated for IGM groups.

27* or U — Bottom boundary albedo data /IMxIGM/ {B04 = 5}

Data are entered in same order as 26* or U array.

28$ — Zones of Convergence /A10/ {A10 > 0}
The zone numbers specified as zones of convergence must appear in the 8$ array of data.

<u>Terminate Card</u>

This concludes the required input data for a calculation.

2.2.3 Problem Size Determination

To determine the number of data locations required for a given problem (and therefore, the value required for the parameter, ISIZE on Card 1, of Data Set 1) each of the expressions below should be evaluated and summed.

(1) $= \{ (A04) \cdot (8 + (2 \cdot JM) + (3 \cdot IM)) \}$

(2) $= \{ IM ((8 \cdot JM) + 8) + (4 \cdot JM) + (16 \cdot IGM) + (2 \cdot M05) + (2 \cdot IZM) + (3 \cdot M01) + 18 \}$

IF $(IHS - IHT - 1) > 0$

(3) $= (ITL + 1)\, MT$

IF $(IHS - IHT - 1) \leq 0$

(3) $= ITL \cdot MT$

IF $A03 > 0$

(4) $= \left\{ \frac{A03 \cdot (A03 + 3)}{2} * \left[A04 + ((3 \cdot IM) \cdot JM) \right] + 1 \right\}$

IF $A03 \leq 0$

(4) $= 1$

IF $IAFT > 0$

(5) $= \left(A04 \cdot \frac{IM}{2} \right)$

IF $IAFT \leq 0$

(5) $= 0$

IF $I04 = 4$

(6) $= (IM + IZ + JM + JZ)$

IF $I04 \neq 4$

(6) $= 0$

IF $B02 = 4$

(7) $= JM * \left[(A04/2) + A07 + A08 \right]$

IF $B02 \neq 4$

(7) $= 0$

IF $B03 = 4$

(8) = [IM · A06]

IF B03 $\neq$ 4

(8) = 0

IF B02 or B03 = 4

(9) = [IGM + 1]

IF B02 or B03 $\neq$ 4

(9) = 0

IF A09 = 2 and A03 $\neq$ 0

(10) = [5*IM*JM]

IF A09 = 2 and A03 = 0

(10) = [6*IM*JM]

IF A09 = 1 or A09 = 3

(10) [IM*JM]

IF A09 = 0

(10) = 0

Next, the following equation should be evaluated:

(11) JLAST = Eq (1) = Eq (2) = Eq (3) + Eq (4) = Eq (5) + Eq (6) + Eq (7) + Eq (8) + Eq (9) + Eq (10)

Then the user should evaluate the following equation, particularly if a large amount of cross sections are to be used:

(12) (1) KLAST =[MT · ITLJ (*) · (IGM + 1)]

The amount of variable dimension data storage required by the DOT-IIW code is either JLAST or KLAST, whichever is greater.

(*)ITLJ = ITL for problems without upscatter; ITLJ = ITL + 1 for problems with upscatter.

2.2.4 Description of Quadrature Data Sets

This section presents a description of the discrete ordinates quadrature input data required for DOT-IIW calculations. Additional information describing the surface angular fluxes is included because these data interface with other computer codes.

Symmetric Quadrature Sets

Angular fluxes are obtained by the DOT-IIW code at mesh points in each mesh cell in the calculation geometry. These fluxes are discrete direction fluxes with directions representative of points on the unit sphere. In obtaining a numerical solution of the Boltzmann transport equation, integration of the continuous variable, $\vec{\Omega}$, is performed by mechanical quadrature, where the continuous variable, $\vec{\Omega}$, is represented by a set of discrete directions (Ω_s) and a corresponding set of weights (p_s). This mechanical quadrature representation is achieved by using a set of direction cosines ($\mu_m \eta_m$) for the discrete directions (Ω_s) and a set of level weights (w_m) for the sum of the point weights (p_s) are the level m.

In solving for angular fluxes in an r - z, two-dimensional mesh cell description, each mesh cell is as indicated in Figure 2-2. Due to symmetry in the angle, θ, point solutions are required only at points A, B, C, D, and P in the finite-volume, mesh cell shown. Points A, B, C, and D are midpoints of each surface of the mesh cell. The angular fluxes obtained at each of these points are then used to calculate the angular and scalar flux at the midpoint of mesh cell, P.

At A, B, C, and D, the angular flux is calculated for a hemisphere of the unit sphere centered about each point. The hemisphere is divided into its four octants as shown in Figure 2-3. These octants represent an S_6 order angular quadrature in r - z geometry. The numbers in the circles in Figure 2-3 represent points at which the angular fluxes are obtained in the DOT-IIW S_6 solution. As shown in the figure, the unit vectors (μ, η, ξ) are represented in an S_6 angular quadrature as cosines, μ_1, μ_2, μ_3, η_1, η_2, η_3, ξ_1, ξ_2, ξ_3. With the same distribution of μ_i, η_i, ξ_i on each unit vector, the discrete directions on the surface of the hemisphere lie on latitudes which maintain rotational symmetry about all axes in the hemisphere. No check on rotational symmetry is made by the DOT-IIW code; the user must verify independently the validity of other quadrature data than presented in this section for his calculation.

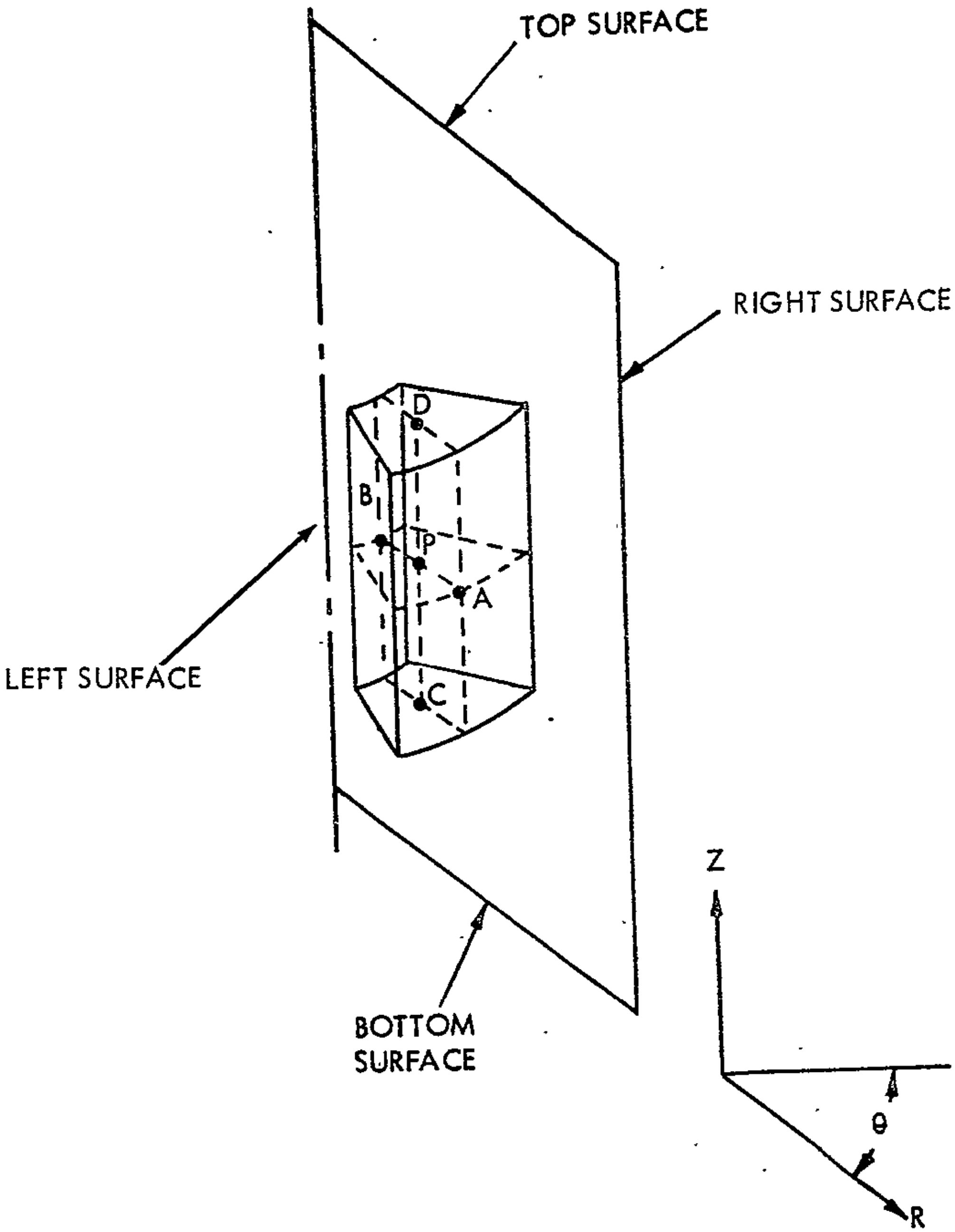

Figure 2-2. R-Z Mesh Cell Description

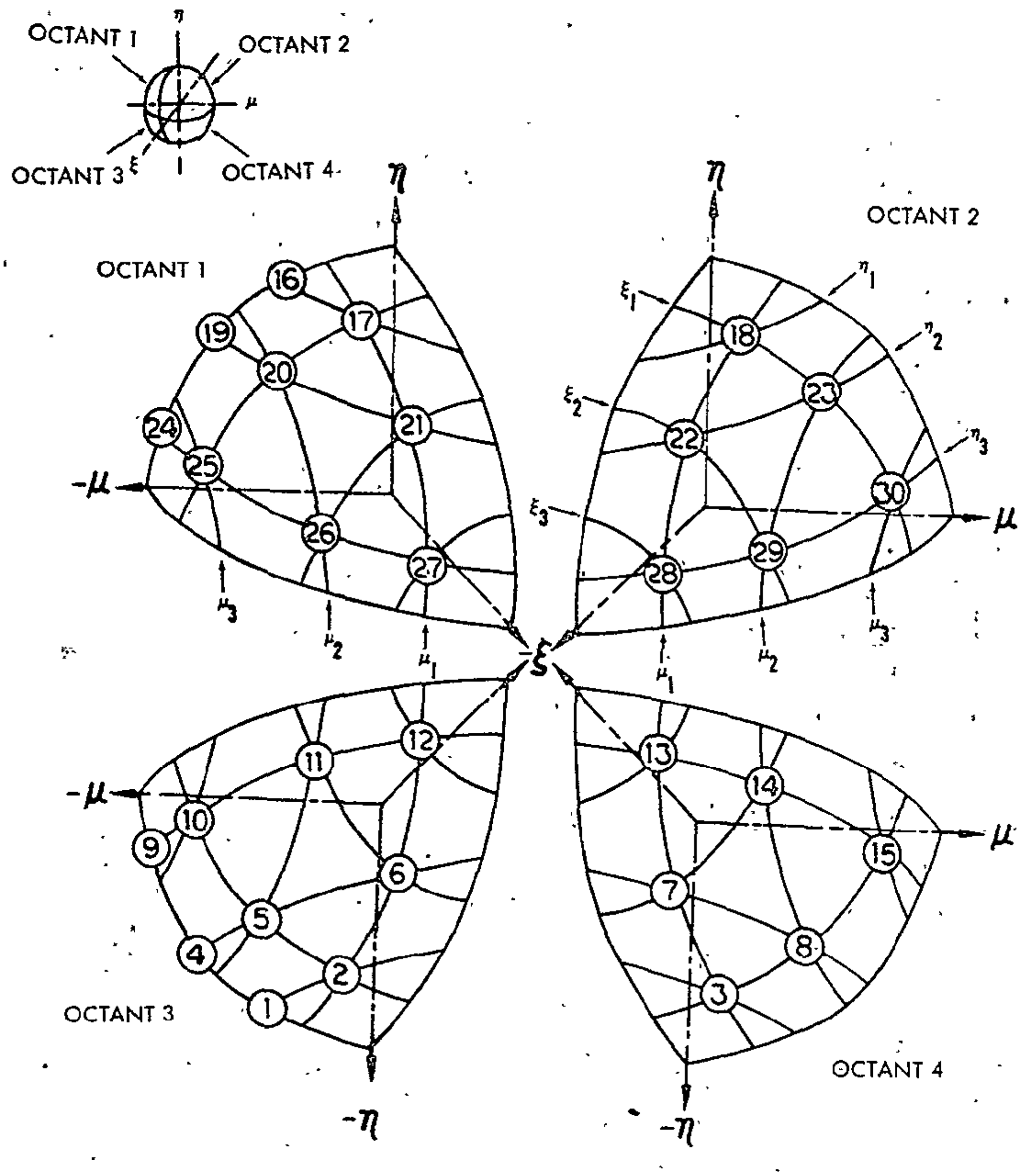

Figure 2-3. DOT-IIW Discrete Directions for R-Z and X-Y Geometries

The requirements for rotation-reflection invariance with respect to 90° axis rotations and with respect to reflections about an axis, and the origin are important concepts in the selection of a generalized quadrature data set. It is convenient and desirable to use a standard set of mechanical quadrature data that in no way biases the results with respect to geometrical axis. For this reason, a set of completely symmetric quadrature data sets satisfying certain even moment conditions(4) as well as rotational invariance were developed(5) and calculated in the form necessary for use in the DOT-IIW code. These sets are present in Table 2-1 for r, z, and x, y two-dimensional geometries and in Table 2-2 for r, θ geometries.

The DOT-IIW code requires that:

(1) $$\sum_{m=1}^{M} w_m = 1.0$$

that:

(2) $$\sum_{m=1}^{M} \eta_m \mu_m w_m = 0.0$$

and that:

(3) $\mu_m \neq 0.0$ and $\eta_m \neq 0$ for all m

In addition to satisfying the above three equations, the quadrature data sets presented in Tables 2-1 and 2-2 satisfy the requirement of rotation-reflection invariance as well as satisfying the "diffusion theory" condition:

(4) $$\sum_{m=1}^{M} w_m \mu_m^2 = 1/3$$

TABLE 2-1

COMPLETELY SYMMETRIC QUADRATURE SETS SATISFYING CERTAIN EVEN MOMENT CONDITIONS FOR X, Y AND R, Z GEOMETRIES

(Sheet 1 of 5)

S2 ANGULAR QUADRATURE

```
 7U
-0.816500000-0.577350000 0.577350000-0.816500000-0.577350000 0.57735000
-0.577350000-0.577350000-0.577350000 0.577350000 0.577350000 0.577350000
  T
 6U
 0.000000000 0.250000000 0.250000000 0.000000000 0.250000000 0.250000000
  T
```

S4 ANGULAR QUADRATURE

```
 7U
-.495004728 -.350021200  .350021200 -.936741778 -.868890280 -.350021200
 .350021200  .868890280 -.495004728 -.350021200  .350021200 -.936741778
-.868890280 -.350021200  .350021200  .868890280
-.868890280 -.868890280 -.868890280 -.350021200 -.350021200 -.350021200
-.350021200 -.350021200  .868890280  .868890280  .868890280  .350021200
 .350021200  .350021200  .350021200  .350021200
  T
 6U
 0.000000000  .083333333  .083333333 0.000000000  .083333333  .083333333
 .083333333  .083333333 0.000000000  .083333333  .083333333 0.000000000
 .083333333  .083333333  .083333333  .083333333
  T
```

TABLE 2-1

S6 ANGULAR QUADRATURE

7U

-.377079540	-.266635500	.266635500	-.731810935	-.681507707	-.266635500
.266635500	.681507707	-.963797442	-.926180879	-.681507707	-.266635500
.266635500	.681507707	.926180879	-.377079540	-.266635500	.266635500
-.731810935	-.681507707	-.266635500	.266635500	.681507707	-.963797442
-.926180879	-.681507707	-.266635500	.266635500	.681507707	.926180879
-.926180879	-.926180879	-.926180879	-.681507707	-.681507707	-.681507707
-.681507707	-.681507707	-.266635500	-.266635500	-.266635500	-.266635500
-.266635500	-.266635500	-.266635500	.926180879	.926180879	.926180879
.681507707	.681507707	.681507707	.681507707	.681507707	.266635500
.266635500	.266635500	.266635500	.266635500	.266635500	.266635500

T

6U

0.000000000	.044031561	.044031561	0.000000000	.039301772	.039301772
.039301772	.039301772	0.000000000	.044031561	.039301772	.044031561
.044031561	.039301772	.044031561	0.000000000	.044031561	.044031561
0.000000000	.039301772	.039301772	.039301772	.039301772	0.000000000
.044031561	.039301772	.044031561	.044031561	.039301772	.044031561

T

S8 ANGULAR QUADRATURE

7U

-.308606714	-.218217900	.218217900	-.617213403	-.577350269	-.218217900
.218217900	.577350269	-.816496581	-.786795790	-.577350269	-.218217900
.218217900	.577350269	.786795790	-.975900071	-.951189727	-.786795790
-.577350269	-.218217900	.218217900	.577350269	.786795790	.951189727
-.308606714	-.218217900	.218217900	-.617213403	-.577350269	-.218217900
.218217900	.577350269	-.816496581	-.786795790	-.577350269	-.218217900
.218217900	.577350269	.786795790	-.975900071	-.951189727	-.786795790
-.577350269	-.218217900	.218217900	.577350269	.786795790	.951189727
-.951189727	-.951189727	-.951189727	-.786795790	-.786795790	-.786795790
-.786795790	-.786795790	-.577350269	-.577350269	-.577350269	-.577350269
-.577350269	-.577350269	-.577350269	-.218217900	-.218217900	-.218217900
-.218217900	-.218217900	-.218217900	-.218217900	-.218217900	-.218217900
.951189727	.951189727	.951189727	.786795790	.786795790	.786795790
.786795790	.786795790	.577350269	.577350269	.577350269	.577350269
.577350269	.577350269	.577350269	.218217900	.218217900	.218217900
.218217900	.218217900	.218217900	.218217900	.218217900	.218217900

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6U

0.000000000	.030246915	.030246915	0.000000000	.022685185	.022685185
.022685185	.022685185	0.000000000	.022685185	.023148144	.022685185
.022685185	.023148144	.022685185	0.000000000	.030246915	.022685185
.022685185	.030246915	.030246915	.022685185	.022685185	.030246915
0.000000000	.030246915	.030246915	0.000000000	.022685185	.022685185
.022685185	.022685185	0.000000000	.022685185	.023148144	.022685185
.022685185	.023148144	.022685185	0.000000000	.030246915	.022685185
.022685185	.030246915	.030246915	.022685185	.022685185	.030246915

T

TABLE 2-1

(Sheet 3 of 5)

S12 ANGULAR QUADRATURE

7U

-.236474327	-.167212600	.167212600	-.489023594	-.459547627	-.167212600
.167212600	.459547627	-.649898487	-.628019099	-.459547627	-.167212600
.167212600	.459547627	.628019099	-.778197925	-.760021024	-.628019099
-.459547627	-.167212600	.167212600	.459547627	.628019099	.760021024
-.888153128	-.872270557	-.760021024	-.628019099	-.459547627	-.167212600
.167212600	.459547627	.628019099	.760021024	.872270557	-.985920862
-.971637737	-.872270557	-.760021024	-.628019099	-.459547627	-.167212600
.167212600	.459547627	.628019099	.760021024	.872270557	.971637737
-.236474327	-.167212600	.167212600	-.489023594	-.459547627	-.167212600
.167212600	.459547627	-.649898487	-.628019099	-.459547627	-.167212600
.167212600	.459547627	.628019099	-.778197925	-.760021024	-.628019099
-.459547627	-.167212600	.167212600	.459547627	.628019099	.760021024
-.888153128	-.872270557	-.760021024	-.628019099	-.459547627	-.167212600
.167212600	.459547627	.628019099	.760021024	.872270557	-.985920862
-.971637737	-.872270557	-.760021024	-.628019099	-.459547627	-.167212600
.167212600	.459547627	.628019099	.760021024	.872270557	.971637737
-.971637737	-.971637737	-.971637737	-.872270557	-.872270557	-.872270557
-.872270557	-.872270557	-.760021024	-.760021024	-.760021024	-.760021024
-.760021024	-.760021024	-.760021024	-.628019099	-.628019099	-.628019099
-.628019099	-.628019099	-.628019099	-.628019099	-.628019099	-.628019099
-.459547627	-.459547627	-.459547627	-.459547627	-.459547627	-.459547627
-.459547627	-.459547627	-.459547627	-.459547627	-.459547627	-.167212600
-.167212600	-.167212600	-.167212600	-.167212600	-.167212600	-.167212600
-.167212600	-.167212600	-.167212600	-.167212600	-.167212600	-.167212600
.971637737	.971637737	.971637737	.872270557	.872270557	.872270557
.872270557	.872270557	.760021024	.760021024	.760021024	.760021024
.760021024	.760021024	.760021024	.628019099	.628019099	.628019099
.628019099	.628019099	.628019099	.628019099	.628019099	.628019099
.459547627	.459547627	.459547627	.459547627	.459547627	.459547627
.459547627	.459547627	.459547627	.459547627	.459547627	.167212600
.167212600	.167212600	.167212600	.167212600	.167212600	.167212600
.167212600	.167212600	.167212600	.167212600	.167212600	.167212600

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6U

0.000000000	.017690641	.017690641	0.000000000	.013970277	.013970277
.013970277	.013970277	0.000000000	.009334415	.012570495	.009334415
.009334415	.012570495	.009334415	0.000000000	.009334415	.006462814
.006462814	.009334415	.009334415	.006462814	.006462814	.009334415
0.000000000	.013970277	.012570495	.006462814	.012570495	.013970277
.013970277	.012570495	.006462814	.012570495	.013970277	0.000000000
.017690641	.013970277	.009334415	.009334415	.013970277	.017690641
.017690641	.013970277	.009334415	.009334415	.013970277	.017690641
0.000000000	.017690641	.017690641	0.000000000	.013970277	.013970277
.013970277	.013970277	0.000000000	.009334415	.012570495	.009334415
.009334415	.012570495	.009334415	0.000000000	.009334415	.006462814
.006462814	.009334415	.009334415	.006462814	.006462814	.009334415
0.000000000	.013970277	.012570495	.006462814	.012570495	.013970277
.013970277	.012570495	.006462814	.012570495	.013970277	0.000000000
.017690641	.013970277	.009334415	.009334415	.013970277	.017690641
.017690641	.013970277	.009334415	.009334415	.013970277	.017690641

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TABLE 2-1

S16 ANGULAR QUADRATURE

7U

-.196514591	-.138956800	.138956800	-.416172855	-.392289246	-.138956800
.138956800	.392289246	-.554780772	-.537096559	-.392289246	-.138956800
.138956800	.392289246	.537096559	-.665104177	-.650426455	-.537096559
-.392289246	-.138956800	.138956800	.392289246	.537096559	.650426455
-.759569237	-.746750584	-.650426455	-.537096559	-.392289246	-.138956800
.138956800	.392289246	.537096559	.650426455	.746750584	-.843520768
-.831996571	-.746750584	-.650426455	-.537096559	-.392289246	-.138956800
.138956800	.392289246	.537096559	.650426455	.746750584	.831996571
-.919841914	-.909285519	-.831996571	-.746750584	-.650426455	-.537096559
-.392289246	-.138956800	.138956800	.392289246	.537096559	.650426455
.746750584	.831996571	.909285519	-.990298444	-.980500900	-.909285519
-.831996571	-.746750584	-.650426455	-.537096559	-.392289246	-.138956800
.138956800	.392289246	.537096559	.650426455	.746750584	.831996571
.909285519	.980500900	-.196514591	-.138956800	.138956800	-.416172855
-.392289246	-.138956800	.138956800	.392289246	-.554780772	-.537096559
-.392289246	-.138956800	.138956800	.392289246	.537096559	-.665104177
-.650426455	-.537096559	-.392289246	-.138956800	.138956800	.392289246
.537096559	.650426455	-.759569237	-.746750584	-.650426455	-.537096559
-.392289246	-.138956800	.138956800	.392289246	.537096559	.650426455
.746750584	-.843520768	-.831996571	-.746750584	-.650426455	-.537096559
-.392289246	-.138956800	.138956800	.392289246	.537096559	.650426455
.746750584	.831996571	-.919841914	-.909285519	-.831996571	-.746750584
-.650426455	-.537096559	-.392289246	-.138956800	.138956800	.392289246
.537096559	.650426455	.746750584	.831996571	.909285519	-.990298444
-.980500900	-.909285519	-.831996571	-.746750584	-.650426455	-.537096559
-.392289246	-.138956800	.138956800	.392289246	.537096559	.650426455
.746750584	.831996571	.909285519	.980500900		
-.980500900	-.980500900	-.980500900	-.909285519	-.909285519	-.909285519
-.909285519	-.909285519	-.831996571	-.831996571	-.831996571	-.831996571
-.831996571	-.831996571	-.831996571	-.746750584	-.746750584	-.746750584
-.746750584	-.746750584	-.746750584	-.746750584	-.746750584	-.746750584
-.650426455	-.650426455	-.650426455	-.650426455	-.650426455	-.650426455
-.650426455	-.650426455	-.650426455	-.650426455	-.650426455	-.537096559
-.537096559	-.537096559	-.537096559	-.537096559	-.537096559	-.537096559
-.537096559	-.537096559	-.537096559	-.537096559	-.537096559	-.537096559
-.392289246	-.392289246	-.392289246	-.392289246	-.392289246	-.392289246
-.392289246	-.392289246	-.392289246	-.392289246	-.392289246	-.392289246
-.392289246	-.392289246	-.392289246	-.138956800	-.138956800	-.138956800
-.138956800	-.138956800	-.138956800	-.138956800	-.138956800	-.138956800
-.138956800	-.138956800	-.138956800	-.138956800	-.138956800	-.138956800
-.138956800	-.138956800	.980500900	.980500900	.980500900	.909285519
.909285519	.909285519	.909285519	.909285519	.831996571	.831996571
.831996571	.831996571	.831996571	.831996571	.831996571	.746750584
.746750584	.746750584	.746750584	.746750584	.746750584	.746750584
.746750584	.746750584	.650426455	.650426455	.650426455	.650426455
.650426455	.650426455	.650426455	.650426455	.650426455	.650426455
.650426455	.537096559	.537096559	.537096559	.537096559	.537096559
.537096559	.537096559	.537096559	.537096559	.537096559	.537096559
.537096559	.537096559	.392289246	.392289246	.392289246	.392289246
.392289246	.392289246	.392289246	.392289246	.392289246	.392289246
.392289246	.392289246	.392289246	.392289246	.392289246	.138956800
.138956800	.138956800	.138956800	.138956800	.138956800	.138956800
.138956800	.138956800	.138956800	.138956800	.138956800	.138956800
.138956800	.138956800	.138956800	.138956800		

TABLE 2-1

(Sheet 5 of 5)

T
6U

0.000000000	.012246801	.012246801	0.000000000	.010332403	.010332403
.010332403	.010332403	0.000000000	.005075791	.009476891	.005075791
.005075791	.009476891	.005075791	0.000000000	.006637520	.003382350
.003382350	.006637520	.006637520	.003382350	.003382350	.006637520
0.000000000	.006637520	.008159281	.002594232	.008159281	.006637520
.006637520	.008159281	.002594232	.008159281	.006637520	0.000000000
.005075791	.003382350	.002594232	.002594232	.003382350	.005075791
.005075791	.003382350	.002594232	.002594232	.003382350	.005075791
0.000000000	.010332403	.009476891	.003382350	.008159281	.003382350
.009476891	.010332403	.010332403	.009476891	.003382350	.008159281
.003382350	.009476891	.010332403	0.000000000	.012246801	.010332403
.005075791	.006637520	.006637520	.005075791	.010332403	.012246801
.012246801	.010332403	.005075791	.006637520	.006637520	.005075791
.010332403	.012246801	0.000000000	.012246801	.012246801	0.000000000
.010332403	.010332403	.010332403	.010332403	0.000000000	.005075791
.009476891	.005075791	.005075791	.009476891	.005075791	0.000000000
.006637520	.003382350	.003382350	.006637520	.006637520	.003382350
.003382350	.006637520	0.000000000	.006637520	.008159281	.002594232
.008159281	.006637520	.006637520	.008159281	.002594232	.008159281
.006637520	0.000000000	.005075791	.003382350	.002594232	.002594232
.003382350	.005075791	.005075791	.003382350	.002594232	.002594232
.003382350	.005075791	0.000000000	.010332403	.009476891	.003382350
.008159281	.003382350	.009476891	.010332403	.010332403	.009476891
.003382350	.008159281	.003382350	.009476891	.010332403	0.000000000
.012246801	.010332403	.005075791	.006637520	.006637520	.005075791
.010332403	.012246801	.012246801	.010332403	.005075791	.006637520
.006637520	.005075791	.010332403	.012246801		

T

TABLE 2-2

COMPLETELY SYMMETRIC QUADRATURE SETS SATISFYING CERTAIN EVEN MOMENT CONDITIONS FOR R, THETA GEOMETRY

(Sheet 1 of 2)

S2 ANGULAR QUADRATURE

```
 7U
   -0.81650     -0.57735     +0.57735     -0.81650     -0.57735     +0.57735
-0.000000001     -0.57735     -0.57735  0.000000001     +0.57735     +0.57735
  T
 6U
    0.00000      0.25000      0.25000      0.00000      0.25000      0.25000
  T
```

S4 ANGULAR QUADRATURE

```
 7U
-0.936741778-0.868890280-0.350021200+0.350021200+0.868890280-0.495004728
-0.350021200+0.350021200-0.936741776-0.868890280-0.350021200+0.350021200
+0.868890260-0.495004728-0.350021200+0.350021200
-0.000000001-0.350021200-0.868890280-0.868890280-0.350021200-0.000000001
-0.350021200-0.350021200 0.000000001+0.350021200+0.868890280+0.868890280
+0.350021200 0.000000001+0.350021200+0.350021200
  T
 6U
 0.000000000 0.083333333 0.083333333 0.083333333 0.083333333 0.000000000
 0.083333333 0.083333333 0.000000000 0.083333333 0.083333333 0.083333333
 0.083333333 0.000000000 0.083333333 0.083333333
  T
```

TABLE 2-2

(Sheet 2 of 2)

S6 ANGULAR CUADRATURE

```
 7U
-0.963797442-0.926180879-0.681507707-0.266635500+0.266635500+0.681507707
+0.926180879-0.731810935-0.681507707-0.266635500+0.266635500+0.681507707
-0.377079540-0.266635500+0.266635500-0.963797442-0.926180879-0.681507707
-0.266635500+0.266635500+0.681507707+0.926180879-0.731810935-0.681507707
-0.266635500+0.266635500+0.681507707-0.377079540-0.266635500+0.266635500
-0.000000001-0.266635500-0.681507707-0.926180879-0.926180879-0.681507707
-0.266635500-0.000000001-0.266635500-0.681507707-0.681507707-0.266635500
-0.000000001-0.266635500-0.266635500 0.000000001+0.266635500+0.681507707
+0.926180879+0.926180879+0.681507707+0.266635500 0.000000001+0.266635500
+0.681507707+0.681507707+0.266635500 0.000000001+0.266635500+0.266635500
  T
 6U
 0.000000000 0.044031561 0.039301772 0.044031561 0.044031561 0.039301772
 0.044031561 0.000000000 0.039301772 0.039301772 0.039301772 0.039301772
 0.000000000 0.044031561 0.044031561 0.000000000 0.044031561 0.039301772
 0.044031561 0.044031561 0.039301772 0.044031561 0.000000000 0.039301772
 0.039301772 0.039301772 0.039301772 0.000000000 0.044031561 0.044031561
  T
```

S8 ANGULAR CUADRATURE

```
 7U
-0.975900071-0.951189727-0.786795790-0.577350269-0.218217900+0.218217900
+0.577350269+0.786795790+0.951189727-0.816496581-0.786795790-0.577350269
-0.218217900+0.218217900+0.577350269+0.786795790-0.617213403-0.577350269
-0.218217900+0.218217900+0.577350269-0.308606714-0.218217900+0.218217900
-0.975900071-0.951189727-0.786795790-0.577350269-0.218217900+0.218217900
+0.577350269+0.786795790+0.951189727-0.816496581-0.786795790-0.577350269
-0.218217900+0.218217900+0.577350269+0.786795790-0.617213403-0.577350269
-0.218217900+0.218217900+0.577350269-0.308606714-0.218217900+0.218217900
-0.000000001-0.218217900-0.577350269-0.786795790-0.951189727-0.951189727
-0.786795790-0.577350269-0.218217900-0.000000001-0.218217900-0.577350269
-0.786795790-0.786795790-0.577350269-0.218217900-0.000000001-0.218217900
-0.577350269-0.577350269-0.218217900-0.000000001-0.218217900-0.218217900
 0.000000001+0.218217900+0.577350269+0.786795790+0.951189727+0.951189727
+0.786795790+0.577350269+0.218217900 0.000000001+0.218217900+0.577350269
+0.786795790+0.786795790+0.577350269+0.218217900 0.000000001+0.218217900
+0.577350269+0.577350269+0.218217900 0.000000001+0.218217900+0.218217900
  T
 6U
 0.000000000 0.030246915 0.022685185 0.022685185 0.030246915 0.030246915
 0.022685185 0.022685185 0.030246915 0.000000000 0.022685185 0.023148144
 0.022685185 0.022685185 0.023148144 0.022685185 0.000000000 0.022685185
 0.022685185 0.022685185 0.022685185 0.000000000 0.030246915 0.030246915
 0.000000000 0.030246915 0.022685185 0.022685185 0.030246915 0.030246915
 0.022685185 0.022685185 0.030246915 0.000000000 0.022685185 0.023148144
 0.022685185 0.022685185 0.023148144 0.022685185 0.000000000 0.022685185
 0.022685185 0.022685185 0.022685185 0.000000000 0.030246915 0.030246915
  T
```

Because the differential scatter cross sections are expanded by Legendre polynomials, quadrature sets that correctly integrate Legendre polynomials are required, if anisotropic scattering calculations are performed in DOT-IIW. Otherwise, for example, if the flux was constant in angle, the evaluation of the P_2 moment might give a non-zero result, and neutron balance would be affected. In addition, the isotropic component of the flux could include other contributions from higher moments. In general, for anisotropic scattering, the order of quadrature (n) should be twice as large as the order of scattering (ℓ) and at least S_4.[2] It is recommended that for typical design and analysis calculations, where external nuclear system radiation is a secondary importance, the symmetric quadrature data sets presented in this report be used.

As shown in Figure 2-3 and presented in Table 2-1, an S_6 DOT-IIW solution contains 30 discrete directions. The numerical solution requires an initialization direction which must be solved in each η_i level in the hemisphere. Each of these initialization directions, indicated as 1, 4, 9, 16, 19 and 24 in Figure 2-3, are assigned a quadrature weight of zero and do not enter into the scalar flux solution. Therefore, only 24 angular fluxes with non-zero weights are obtained in the S_6 hemisphere. The integration of the angular flux in DOT-IIW to obtain the scalar flux is simply the summation of the products of angular flux times the appropriate quadrature weight. By comparison, an S_6 order angular quadrature representation in r, θ geometry is shown in Figure 2-4. The reorientation of the quadrature data allows the code to follow the logical flow of particles in the solution plane.

The angular flux data obtained from the DOT-IIW code, for use in the MAP code, are the mesh cell surface data at the outer radius, top surface, inner radius, and bottom surface of the calculation geometry. These data are the angular flux data point A for all the outer radius mesh cells, point C, for all the top surface mesh cells, point B, for all the inner radius mesh cells, and point D, for all the bottom surface mesh cells.

Asymmetric Quadrature Sets

It is sometimes desirable to achieve a high degree of angular flux resolution along a particular axis or axes without paying the penalty of excessive core storage requirements,

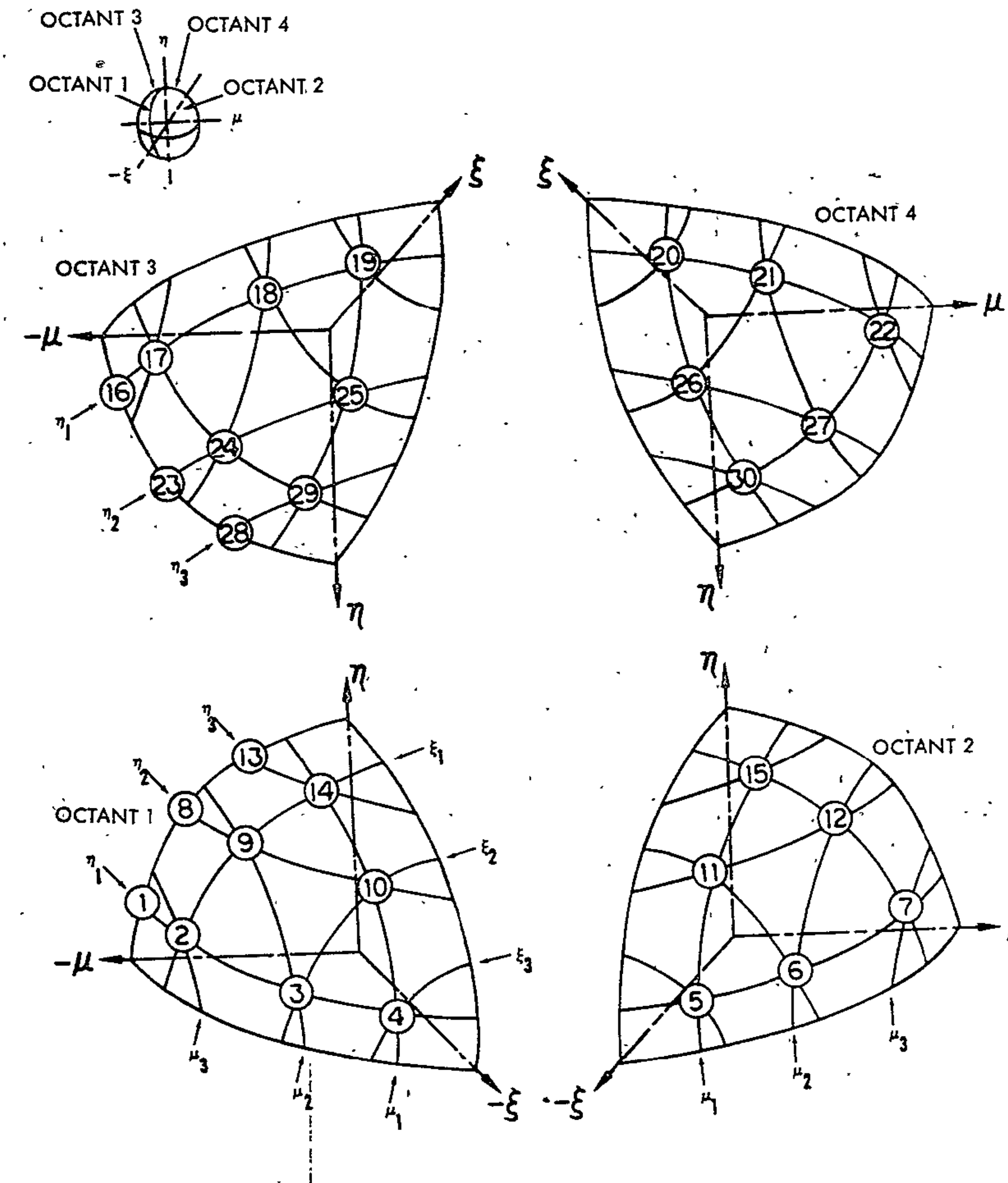

Figure 2-4. DOT-IIW Discrete Directions for R-θ Geometry

or uniform high angular flux resolution with the resulting high expense of computational time. To obtain this angular resolution, certain asymmetric quadrature sets have been developed using the DOQ and ADOQ computer codes described in the Appendixes. These sets are specifically tailored to achieve high angular resolution in the direction of the z axis and contain varying degrees of level resolution. These sets are presented in Table 2-3 for two-dimensional geometries and satisfy equations (1) through (4) inclusive, defined in the previous section on symmetric quadrature sets. Note, however, that a reflective or periodic top or bottom boundary condition cannot be used if the quadrature data are asymmetric about $\eta = 0.0$. If a reflective or periodic boundary condition is specified, the asymmetric quadrature data must have matching angles (ETA mates) in each hemisphere.

Quadrature Data Parameters

Table 2-4 presents the parameters A04, A05, A06, A07, and A08 as required by the DOT-IIW code for all the quadrature sets presented in this report.

2.2.5 Mesh Spacing Requirements[6]

The use of an adequate mesh spacing in a DOT-IIW calculation is mandatory to obtain an accurate solution of the flux and resultant fission distribution while conserving available core data storage. To eliminate (or reduce) negative angular and/or scalar fluxes that result from an inadequate mesh spacing, a few simple rules to define the proper mesh line spacing are presented here. Where core memory storage limitations prevent the implementation of these guidelines, the techniques to define the minimum necessary mesh spacing for the DOT-IIW are illustrated. Negative angular and/or scalar flux solutions may still occur even though these guidelines are followed, but the occurrence of the negative fluxes and their resultant effect on the true solution will be minimized. The empirical relationships (Criteria 1 and 2) are stringent, requiring a considerable amount of intuitive judgement in their use.

TABLE 2-3

ASYMMETRIC QUADRATURE SETS SATISFYING CERTAIN EVEN MOMENT COMDITIONS WHICH ACHIEVE HIGH ANGULAR RESOLUTION IN THE DIRECTION OF THE Z AXIS (IN THE OPPOSITE HEMISPHERE, A COMPLETELY SYMMETRIC S6 QUADRATURE SET IS USED.)

(Sheet 1 of 22)

80 ANGLES 49 DEGREES ON A LEVEL
15 ANGLES IN THE +ETA DIRECTION, 65 ANGLES IN THE -ETA DIRECTION

7U					
-.024917777	-.016347532	.016347532	-.057171433	-.037507835	.037507835
-.085555393	-.058753624	.058753624	-.121887680	-.079965513	.079965513
-.154107249	-.101103452	.101103452	-.186171501	-.122139494	.122139494
-.218042951	-.143049047	.143049047	-.249686111	-.163808828	.163808828
-.281066512	-.184396223	.184396223	-.312150340	-.204789049	.204789049
-.342904308	-.224965467	.224965467	-.501663000	-.433395000	-.148874000
.148874000	.433395000	-.733759000	-.679410000	-.433395000	-.148874000
.148874000	.433395000	.679410000	-.901204000	-.865063000	-.679410000
-.433395000	-.148874000	.148874000	.433395000	.679410000	.865063000
-.988856000	-.973907000	-.865063000	-.679410000	-.433395000	-.148874000
.148874000	.433395000	.679410000	.865063000	.973907000	-.361249000
-.238619000	.238619000	-.750201000	-.661209000	-.238619000	.238619000
.661209000	-.971113000	-.932470000	-.661209000	-.238619000	.238619000
.661209000	.932470000				
-.999689504	-.999689504	-.999689504	-.998364376	-.998364376	-.998364376
-.995981843	-.995981843	-.995981843	-.992543900	-.992543900	-.992543900
-.988054126	-.988054126	-.988054126	-.982517263	-.982517263	-.982517263
-.975939174	-.975939174	-.975939174	-.968326828	-.968326828	-.968326828
-.959688291	-.959688291	-.959688291	-.950032718	-.950032718	-.950032718
-.939370340	-.939370340	-.939370340	-.865063000	-.865063000	-.865063000
-.865063000	-.865063000	-.679410000	-.679410000	-.679410000	-.679410000
-.679410000	-.679410000	-.679410000	-.433395000	-.433395000	-.433395000
-.433395000	-.433395000	-.433395000	-.433395000	-.433395000	-.433395000
-.148874000	-.148874000	-.148874000	-.148874000	-.148874000	-.148874000
-.148874000	-.148874000	-.148874000	-.148874000	-.148874000	.932470000
.932470000	.932470000	.661209000	.661209000	.661209000	.661209000
.661209000	.238619000	.238619000	.238619000	.238619000	.238619000
.238619000	.238619000				
T					
6U					
0.000000000	.000199198	.000199198	0.000000000	.000463490	.000463490
0.000000000	.000727683	.000727683	0.000000000	.000991138	.000991138
0.000000000	.001253551	.001253551	0.000000000	.001514636	.001514636
0.000000000	.001774118	.001774118	0.000000000	.002031719	.002031719
0.000000000	.002287168	.002287168	0.000000000	.002540192	.002540192
0.000000000	.002884906	.002884906	0.000000000	.024441900	.012920900
.012920900	.024441900	0.000000000	.027011100	.008549830	.019210600
.019210600	.008549830	.027011100	0.000000000	.024441900	.008549830
.027468300	.006856610	.006856610	.027468300	.008549830	.024441900
0.000000000	.016667800	.012920900	.019210600	.006856610	.018225100
.018225100	.006856610	.019210600	.012920900	.016667800	0.000000000
.042831100	.042831100	0.000000000	.055238700	.034951700	.034951700
.055238700	0.000000000	.042831100	.034951700	.039195600	.039195600
.034951700	.042831100				
T					

TABLE 2-3

(Sheet 2 of 22)

```
              80  ANGLES                    49 DEGREES ON A LEVEL
     65 ANGLES IN THE +ETA DIRECTION,  15 ANGLES IN THE -ETA DIRECTION

7U
-.361249000 -.238619000  .238619000 -.750201000 -.661209000 -.238619000
 .238619000  .661209000 -.971113000 -.932470000 -.661209000 -.238619000
 .238619000  .661209000  .932470000 -.024917777 -.016347532  .016347532
-.057171433 -.037507835  .037507835 -.089555393 -.058753624  .058753624
-.121687680 -.079965513  .079965513 -.154107249 -.101103452  .101103452
-.186171501 -.122139494  .122139494 -.218042951 -.143049047  .143049047
-.249636111 -.163808828  .163808828 -.281066512 -.184396223  .184396223
-.312150340 -.204789049  .204789049 -.342904308 -.224965467  .224965467
-.501663000 -.433395000 -.148874000  .148874000  .433395000 -.733759000
-.679410000 -.433395000 -.148874000  .148674000  .433395000  .679410000
-.901204000 -.865063000 -.679410000 -.433395000 -.148874000  .148874000
 .433395000  .679410000  .865063000 -.988856000 -.973907000 -.865063000
-.679410000 -.433395000 -.148874000  .148874000  .433395000  .679410000
 .865063000  .973907000
-.932470000 -.932470000 -.932470000 -.661209000 -.661209000 -.661209000
-.661209000 -.661209000 -.238619000 -.238619000 -.238619000 -.238619000
-.238619000 -.238619000 -.238619000  .999689504  .999689504  .999689504
 .998364376  .998364376  .998364376  .995981843  .995981843  .995981843
 .992543900  .992543900  .992543900  .988054126  .988054126  .988054126
 .982517263  .982517263  .982517263  .975939174  .975939174  .975939174
 .968326828  .968326828  .968326828  .959688291  .959688291  .959688291
 .950032718  .950032718  .950032718  .939370340  .939370340  .939370340
 .865063000  .865063000  .865063000  .865063000  .865063000  .679410000
 .679410000  .679410000  .679410000  .679410000  .679410000  .679410000
 .433395000  .433395000  .433395000  .433395000  .433395000  .433395000
 .433395000  .433395000  .433395000  .148874000  .148874000  .148874000
 .148874000  .148874000  .148874000  .148874000  .148874000  .148874000
 .148874000  .148874000
 T
6U
0.000000000  .042831100  .042831100 0.000000000  .055238700  .034951700
 .034951700  .055238700 0.000000000  .042831100  .034951700  .039195600
 .039195600  .034951700  .042831100 0.000000000  .000199198  .000199198
0.000000000  .000463490  .000463490 0.000000000  .000727683  .000727683
0.000000000  .000991138  .000991138 0.000000000  .001253551  .001253551
0.000000000  .001514636  .001514636 0.000000000  .001774118  .001774118
0.000000000  .002031719  .002031719 0.000000000  .002287168  .002287168
0.000000000  .002540192  .002540192 0.000000000  .002884906  .002884906
0.000000000  .024441900  .012920900  .012920900  .024441900 0.000000000
 .027011100  .008549830  .019210600  .019210600  .008549830  .027011100
0.000000000  .024441900  .008549830  .027468300  .006856610  .006856610
 .027468300  .008549830  .024441900 0.000000000  .016667800  .012920900
 .019210600  .006856610  .018225100  .018225100  .006856610  .019210600
 .012920900  .016667800
 T
```

TABLE 2-3

(Sheet 3 of 22)

```
           102 ANGLES                     1,49 DEGREES ON A LEVEL
    87 ANGLES IN THE +ETA DIRECTION,  15 ANGLES IN THE -ETA DIRECTION

7U
-.024917777 -.024913982 -.016347532  .016347532  .024913982 -.057171433
-.057162725 -.037507835  .037507835  .057162725 -.089555393 -.089541753
-.058753624  .058753624  .089541753 -.121887680 -.121869116 -.079965513
 .079965513  .121869116 -.154107249 -.154083777 -.101103452  .101103452
 .154083777 -.186171501 -.186143147 -.122139494  .122139494  .186143147
-.218042951 -.218009742 -.143049047  .143049047  .218009742 -.249686111
-.249648083 -.163808828  .163808828  .249648083 -.281066512 -.281023704
-.184396223  .184396223  .281023704 -.312150340 -.312102798 -.204789049
 .204789049  .312102798 -.342904308 -.342852082 -.224965467  .224965467
 .342852082 -.501663000 -.433395000 -.148874000  .148874000  .433395000
-.733759000 -.679410000 -.433395000 -.148874000  .148874000  .433395000
 .679410000 -.901204000 -.865063000 -.679410000 -.433395000 -.148874000
 .148674000  .433395000  .679410000  .865063000 -.988856000 -.973907000
-.865063000 -.679410000 -.433395000 -.148874000  .148874000  .433395000
 .679410000  .865063000  .973907000 -.361249000 -.238619000  .238619000
-.750201000 -.661209000 -.238619000  .238619000  .661209000 -.971113000
-.932470000 -.661209000 -.238619000  .238619000  .661209000  .932470000
-.999689504 -.999689504 -.999689504 -.999689504 -.999689504 -.998364376
-.998364376 -.998364376 -.998364376 -.998364376 -.995981843 -.995981843
-.995981843 -.995981843 -.995981843 -.992543900 -.992543900 -.992543900
-.992543900 -.992543900 -.988054126 -.988054126 -.988054126 -.988054126
-.988054126 -.982517263 -.982517263 -.982517263 -.982517263 -.982517263
-.975939174 -.975939174 -.975939174 -.975939174 -.975939174 -.968326828
-.968326828 -.968326828 -.968326828 -.968326828 -.959688291 -.959688291
-.959688291 -.959688291 -.959688291 -.950032718 -.950032718 -.950032718
-.950032718 -.950032718 -.939370340 -.939370340 -.939370340 -.939370340
-.939370340 -.865063000 -.865063000 -.865063000 -.865063000 -.865063000
-.679410000 -.679410000 -.679410000 -.679410000 -.679410000 -.679410000
-.679410000 -.433395000 -.433395000 -.433395000 -.433395000 -.433395000
-.433395000 -.433395000 -.433395000 -.433395000 -.148874000 -.148874000
-.148874000 -.148874000 -.148874000 -.148874000 -.148874000 -.148874000
-.148874000 -.148874000 -.148874000  .932470000  .932470000  .932470000
 .661209000  .661209000  .661209000  .661209000  .661209000  .238619000
 .238619000  .238619000  .238619000  .238619000  .238619000  .238619000
 T
6U
0.000000000  .000004427  .000194771  .000194771  .000004427 0.000000000
 .000010300  .000453190  .000453190  .000010300 0.000000000  .000016171
 .000711512  .000711512  .000016171 0.000000000  .000022025  .000969113
 .000969113  .000022025 0.000000000  .000027857  .001225694  .001225694
 .000027857 0.000000000  .000033659  .001480978  .001480978  .000033659
0.000000000  .000039425  .001734693  .001734693  .000039425 0.000000000
 .000045149  .001986570  .001986570  .000045149 0.000000000  .000050826
 .002236342  .002236342  .000050826 0.000000000  .000056449  .002483744
 .002483744  .000056449 0.000000000  .000064109  .002820797  .002820797
 .000064109 0.000000000  .024441900  .012920900  .012920900  .024441900
0.000000000  .027011100  .008549830  .019210600  .019210600  .008549830
 .027011100 0.000000000  .024441900  .008549830  .027468300  .006856610
 .006856610  .027468300  .008549830  .024441900 0.000000000  .016667800
 .012920900  .019210600  .006856610  .018225100  .018225100  .006856610
 .019210600  .012920900  .016667800 0.000000000  .042831100  .042831100
0.000000000  .055238700  .034951700  .034951700  .055238700 0.000000000
 .042831100  .034951700  .039195600  .039195600  .034951700  .042831100
 T
```

TABLE 2-3

(Sheet 4 of 22)

102 ANGLES 1,49 DEGREES ON A LEVEL
15 ANGLES IN THE +ETA DIRECTION, 87 ANGLES IN THE -ETA DIRECTION

7U

-.361249000	-.238619000	.238619000	-.750201000	-.661209000	-.238619000
.238619000	.661209000	-.971113000	-.932470000	-.661209000	-.238619000
.238619000	.661209000	.932470000	-.024917777	-.024913982	-.016347532
.016347532	.024913982	-.057171433	-.057162725	-.037507835	.037507835
.057162725	-.089555393	-.089541753	-.058753624	.058753624	.089541753
-.121897680	-.121869116	-.079965513	.079965513	.121869116	-.154107249
-.154083777	-.101103452	.101103452	.154083777	-.186171501	-.186143147
-.122139494	.122139494	.186143147	-.218042951	-.218009742	-.143049047
.143049047	.218009742	-.249686111	-.249648083	-.163808828	.163808828
.249648083	-.281066512	-.281023704	-.184396223	.184396223	.281023704
-.312150340	-.312102798	-.204789049	.204789049	.312102798	-.342904308
-.342852082	-.224965467	.224965467	.342852082	-.501663000	-.433395000
-.148874000	.148874000	.433395000	-.733759000	-.679410000	-.433395000
-.148874000	.148874000	.433395000	.679410000	-.901204000	-.865063000
-.679410000	-.433395000	-.148874000	.148874000	.433395000	.679410000
.865063000	-.988856000	-.973907000	-.865063000	-.679410000	-.433395000
-.148874000	.148874000	.433395000	.679410000	.865063000	.973907000
-.932470000	-.932470000	-.932470000	-.661209000	-.661209000	-.661209000
-.661209000	-.661209000	-.238619000	-.238619000	-.238619000	-.238619000
-.238619000	-.238619000	-.238619000	.999689504	.999689504	.999689504
.999689504	.999689504	.998364376	.998364376	.998364376	.998364376
-.998364376	.995981843	.995981843	.995981843	.995981843	.995981843
.992543900	.992543900	.992543900	.992543900	.992543900	.988054126
.988054126	.988054126	.988054126	.988054126	.982517263	.982517263
.982517263	.982517263	.982517263	.975939174	.975939174	.975939174
.975939174	.975939174	.968326828	.968326828	.968326828	.968326828
.968326828	.959688291	.959688291	.959688291	.959688291	.959688291
.950032718	.950032718	.950032718	.950032718	.950032718	.939370340
.939370340	.939370340	.939370340	.939370340	.865063000	.865063000
.865063000	.865063000	.865063000	.679410000	.679410000	.679410000
.679410000	.679410000	.679410000	.679410000	.433395000	.433395000
.433395000	.433395000	.433395000	.433395000	.433395000	.433395000
.433395000	.148874000	.148874000	.148874000	.148874000	.148874000
.148874000	.148874000	.148874000	.148874000	.148874000	.148874000

T

6U

0.000000000	.042831100	.042831100	0.000000000	.055238700	.034951700
.034951700	.055238700	0.000000000	.042831100	.034951700	.039195600
.039195600	.034951700	.042831100	0.000000000	.000004427	.000194771
.000194771	.000004427	0.000000000	.000010300	.000453190	.000453190
.000010300	0.000000000	.000016171	.000711512	.000711512	.000016171
0.000000000	.000022025	.000969113	.000969113	.000022025	0.000000000
.000027857	.001225694	.001225694	.000027857	0.000000000	.000033659
.001480978	.001480978	.000033659	0.000000000	.000039425	.001734693
.001734693	.000039425	0.000000000	.000045149	.001986570	.001986570
.000045149	0.000000000	.000050826	.002236342	.002236342	.000050826
0.000000000	.000056449	.002483744	.002483744	.000056449	0.000000000
.000064109	.002820797	.002820797	.000064109	0.000000000	.024441900
.012920900	.012920900	.024441900	0.000000000	.027011100	.008549830
.019210600	.019210600	.008549830	.027011100	0.000000000	.024441900
.008549830	.027468300	.006856610	.006856610	.027468300	.008549830
.024441900	0.000000000	.016667800	.012920900	.019210600	.006856610
.018225100	.018225100	.006856610	.019210600	.012920900	.016667800

T

TABLE 2-3

(Sheet 5 of 22)

102 ANGLES 2.5,49 DEGREES ON A LEVEL
15 ANGLES IN THE +ETA DIRECTION, 87 ANGLES IN THE -ETA DIRECTION

7U

-.024917777	-.024894060	-.016347532	.016347532	.024894060	-.057171433
-.057117018	-.037507835	.037507835	.057117018	-.089555393	-.089470156
-.058753624	.058753624	.089470156	-.121887680	-.121771670	-.079965513
.079965513	.121771670	-.154107249	-.153960573	-.101103452	.101103452
.153960573	-.186171501	-.185994307	-.122139494	.122139494	.185994307
-.218042951	-.217835423	-.143049047	.143049047	.217835423	-.249686111
-.249448465	-.163808828	.163808828	.249448465	-.281066512	-.280798999
-.184396223	.184396223	.280798999	-.312150340	-.311853242	-.204789049
.204789049	.311853242	-.342904308	-.342577939	-.224965467	.224965467
.342577939	-.501663000	-.433395000	-.148874000	.148874000	.433395000
-.733759000	-.679410000	-.433395000	-.148874000	.148874000	.433395000
.679410000	-.901204000	-.865063000	-.679410000	-.433395000	-.148874000
.148874000	.433395000	.679410000	.865063000	-.988856000	-.973907000
-.865063000	-.679410000	-.433395000	-.148874000	.148874000	.433395000
.679410000	.865063000	.973907000	-.361249000	-.238619000	.238619000
-.750201000	-.661209000	-.238619000	.238619000	.661209000	-.971113000
-.932470000	-.661209000	-.238619000	.238619000	.661209000	.932470000
-.999689504	-.999689504	-.999689504	-.999689504	-.999689504	-.998364376
-.998364376	-.998364376	-.998364376	-.998364376	-.995981843	-.995981843
-.995981843	-.995981843	-.995981843	-.992543900	-.992543900	-.992543900
-.992543900	-.992543900	-.988054126	-.988054126	-.988054126	-.988054126
-.988054126	-.982517263	-.982517263	-.982517263	-.982517263	-.982517263
-.975939174	-.975939174	-.975939174	-.975939174	-.975939174	-.968326828
-.968326828	-.968326828	-.968326828	-.968326828	-.959688291	-.959688291
-.959688291	-.959688291	-.959688291	-.950032718	-.950032718	-.950032718
-.950032718	-.950032718	-.939370340	-.939370340	-.939370340	-.939370340
-.939370340	-.865063000	-.865063000	-.865063000	-.865063000	-.865063000
-.679410000	-.679410000	-.679410000	-.679410000	-.679410000	-.679410000
-.679410000	-.433395000	-.433395000	-.433395000	-.433395000	-.433395000
-.433395000	-.433395000	-.433395000	-.433395000	-.148874000	-.148874000
-.148874000	-.148874000	-.148874000	-.148874000	-.148874000	-.148874000
-.148874000	-.148874000	-.148874000	.932470000	.932470000	.932470000
.661209000	.661209000	.661209000	.661209000	.661209000	.238619000
.238619000	.238619000	.238619000	.238619000	.238619000	.238619000

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6U

0.000000000	.000011067	.000188131	.000188131	.000011067	0.000000000
.000025749	.000437741	.000437741	.000025749	0.000000000	.000040427
.000687256	.000687256	.000040427	0.000000000	.000055063	.000936075
.000936075	.000055063	0.000000000	.000069642	.001183909	.001183909
.000069642	0.000000000	.000084146	.001430490	.001430490	.000084146
0.000000000	.000098562	.001675556	.001675556	.000098562	0.000000000
.000112873	.001918846	.001918846	.000112873	0.000000000	.000127065
.002160103	.002160103	.000127065	0.000000000	.000141122	.002399071
.002399071	.000141122	0.000000000	.000160273	.002724633	.002724633
.000160273	0.000000000	.024441900	.012920900	.012920900	.024441900
0.000000000	.027011100	.008549830	.019210600	.019210600	.008549830
.027011100	0.000000000	.024441900	.008549830	.027468300	.006856610
.006856610	.027468300	.008549830	.024441900	0.000000000	.016667800
.012920900	.019210600	.006856610	.018225100	.018225100	.006856610
.019210600	.012920900	.016667800	0.000000000	.042831100	.042831100
0.000000000	.055238700	.034951700	.034951700	.055238700	0.000000000
.042831100	.034951700	.039195600	.039195600	.034951700	.042831100

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NOT REPRODUCIBLE

TABLE 2-3

102 ANGLES 2.5,49 DEGREES ON A LEVEL
87 ANGLES IN THE +ETA DIRECTION, 15 ANGLES IN THE -ETA DIRECTION

7U

-.361249000	-.238619000	.238619000	-.750201000	-.661209000	-.238619000
.238619000	.661209000	-.971113000	-.932470000	-.661209000	-.238619000
.238619000	.661209000	.932470000	-.024917777	-.024894060	-.016347532
.016347532	.024894060	-.057171433	-.057117018	-.037507835	.037507835
.057117018	-.089555393	-.089470156	-.058753624	.058753624	.089470156
-.121887680	-.121771670	-.079965513	.079965513	.121771670	-.154107249
-.153960573	-.101103452	.101103452	.153960573	-.186171501	-.185994307
-.122139494	.122139494	.185994307	-.218042951	-.217835423	-.143049047
.143049047	.217835423	-.249686111	-.249448465	-.163808828	.163808828
.249448465	-.281066512	-.280798999	-.184396223	.184396223	.280798999
-.312150340	-.311853242	-.204789049	.204789049	.311853242	-.342904308
-.342577939	-.224965467	.224965467	.342577939	-.501663000	-.433395000
-.148874000	.148874000	.433395000	-.733759000	-.679410000	-.433395000
-.148874000	.148874000	.433395000	.679410000	-.901204000	-.865063000
-.679410000	-.433395000	-.148874000	.148874000	.433395000	.679410000
.865063000	-.988856000	-.973907000	-.865063000	-.679410000	-.433395000
-.148874000	.148874000	.433395000	.679410000	.865063000	.973907000
-.932470000	-.932470000	-.932470000	-.661209000	-.661209000	-.661209000
-.661209000	-.661209000	-.238619000	-.238619000	-.238619000	-.238619000
-.238619000	-.238619000	-.238619000	.999689504	.999689504	.999689504
.999689504	.999689504	.998364376	.998364376	.998364376	.998364376
.998364376	.995981843	.995981843	.995981843	.995981843	.995981843
.992543900	.992543900	.992543900	.992543900	.992543900	.988054126
.988054126	.988054126	.988054126	.988054126	.982517263	.982517263
.982517263	.982517263	.982517263	.975939174	.975939174	.975939174
.975939174	.975939174	.968326828	.968326828	.968326828	.968326828
.968326828	.959688291	.959688291	.959688291	.959688291	.959688291
.950032718	.950032718	.950032718	.950032718	.950032718	.939370340
.939370340	.939370340	.939370340	.939370340	.865063000	.865063000
.865063000	.865063000	.865063000	.679410000	.679410000	.679410000
.679410000	.679410000	.679410000	.679410000	.433395000	.433395000
.433395000	.433395000	.433395000	.433395000	.433395000	.433395000
.433395000	.148874000	.148874000	.148874000	.148874000	.148874000
.148874000	.148874000	.148874000	.148874000	.148874000	.148874000

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6U

0.000000000	.042831100	.042831100	0.000000000	.055238700	.034951700
.034951700	.055238700	0.000000000	.042831100	.034951700	.039195600
.039195600	.034951700	.042831100	0.000000000	.000011067	.000188131
.000188131	.000011067	0.000000000	.000025749	.000437741	.000437741
.000025749	0.000000000	.000040427	.000687256	.000687256	.000040427
0.000000000	.000055063	.000936075	.000936075	.000055063	0.000000000
.000069642	.001183909	.001183909	.000069642	0.000000000	.000084146
.001430490	.001430490	.000084146	0.000000000	.000098562	.001675556
.001675556	.000098562	0.000000000	.000112873	.001918846	.001918846
.000112873	0.000000000	.000127065	.002160103	.002160103	.000127065
0.000000000	.000141122	.002399071	.002399071	.000141122	0.000000000
.000160273	.002724633	.002724633	.000160273	0.000000000	.024441900
.012920900	.012920900	.024441900	0.000000000	.027011100	.008549830
.019210600	.019210600	.008549830	.027011100	0.000000000	.024441900
.008549830	.027468300	.006856610	.006856610	.027468300	.008549830
.024441900	0.000000000	.016667800	.012920900	.019210600	.006856610
.018225100	.018225100	.006856610	.019210600	.012920900	.016667800

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TABLE 2-3

(Sheet 7 of 22)

124 ANGLES 1,17.5,49 DEGREES ON A LEVEL
15 ANGLES IN THE +ETA DIRECTION, 109 ANGLES IN THE -ETA DIRECTION

7U

-.024917777	-.024913982	-.023764506	-.012458888	.012458888	.023764506
.024913982	-.057171433	-.057162725	-.054525365	-.028585716	.028585716
.054525365	.057162725	-.089555393	-.089541753	-.085410496	-.044777696
.044777696	.085410496	.089541753	-.121887680	-.121869116	-.116246347
-.060943840	.060943840	.116246347	.121869116	-.154107249	-.154083777
-.146974695	-.077053624	.077053624	.146974695	.154083777	-.186171501
-.186143147	-.177554917	-.093085751	.093085751	.177554917	.186143147
-.218042951	-.218009742	-.207951259	-.109021476	.109021476	.207951259
.218009742	-.249686111	-.249648083	-.238129877	-.124843056	.124843056
.238129877	.249648083	-.281066512	-.281023704	-.268057897	-.140533256
.140533256	.268057897	.281023704	-.312150340	-.312102798	-.297703070
-.156075170	.156075170	.297703070	.312102798	-.342904308	-.342852082
-.327033651	-.171452154	.171452154	.327033651	.342852082	-.501663000
-.433395000	-.148874000	.148874000	.433395000	-.733759000	-.679410000
-.433395000	-.148874000	.148874000	.433395000	.679410000	-.901204000
-.865063000	-.679410000	-.433395000	-.148874000	.148874000	.433395000
.679410000	.865063000	-.988856000	-.973907000	-.865063000	-.679410000
-.433395000	-.148874000	.148874000	.433395000	.679410000	.865063000
.973907000	-.361249000	-.238619000	.238619000	-.750201000	-.661209000
-.238619000	.238619000	.661209000	-.971113000	-.932470000	-.661209000
-.238619000	.238619000	.661209000	.932470000		
-.999689504	-.999689504	-.999689504	-.999689504	-.999689504	-.999689504
-.999689504	-.998364376	-.998364376	-.998364376	-.998364376	-.998364376
-.998364376	-.998364376	-.995981843	-.995981843	-.995981843	-.995981843
-.995981843	-.995981843	-.995981843	-.992543900	-.992543900	-.992543900
-.992543900	-.992543900	-.992543900	-.992543900	-.988054126	-.988054126
-.988054126	-.988054126	-.988054126	-.988054126	-.988054126	-.982517263
-.982517263	-.982517263	-.982517263	-.982517263	-.982517263	-.982517263
-.975939174	-.975939174	-.975939174	-.975939174	-.975939174	-.975939174
-.975939174	-.968326828	-.968326828	-.968326828	-.968326828	-.968326828
-.968326828	-.968326828	-.959688291	-.959688291	-.959688291	-.959688291
-.959688291	-.959688291	-.959688291	-.950032718	-.950032718	-.950032718
-.950032718	-.950032718	-.950032718	-.950032718	-.939370340	-.939370340
-.939370340	-.939370340	-.939370340	-.939370340	-.939370340	-.865063000
-.865063000	-.865063000	-.865063000	-.865063000	-.679410000	-.679410000
-.679410000	-.679410000	-.679410000	-.679410000	-.679410000	-.433395000
-.433395000	-.433395000	-.433395000	-.433395000	-.433395000	-.433395000
-.433395000	-.433395000	-.148874000	-.148874000	-.148874000	-.148874000
-.148874000	-.148874000	-.148874000	-.148874000	-.148874000	-.148874000
-.148874000	.932470000	.932470000	.932470000	.661209000	.661209000
.661209000	.661209000	.661209000	.238619000	.238619000	.238619000
.238619000	.238619000	.238619000	.238619000		

TABLE 2-3

(Sheet 8 of 22)

6U

0.000000000	.000004427	.000061973	.000132799	.000132799	.000061973
.000004427	0.000000000	.000010300	.000144197	.000308994	.000308994
.000144197	.000010300	0.000000000	.000016171	.000226390	.000485122
.000485122	.000226390	.000016171	0.000000000	.000022025	.000308354
.000660759	.000660759	.000308354	.000022025	0.000000000	.000027857
.000389994	.000835700	.000835700	.000389994	.000027857	0.000000000
.000033659	.000471220	.001009758	.001009758	.000471220	.000033659
0.000000000	.000039425	.000551948	.001182745	.001182745	.000551948
.000039425	0.000000000	.000045149	.000632090	.001354479	.001354479
.000632090	.000045149	0.000000000	.000050826	.000711563	.001524778
.001524778	.000711563	.000050826	0.000000000	.000056449	.000790282
.001693462	.001693462	.000790222	.000056449	0.000000000	.000064109
.000897526	.001923271	.001923271	.000897526	.000064109	0.000000000
.024441900	.012920900	.012920900	.024441900	0.000000000	.027011100

.008549830	.019210600	.019210600	.008549830	.027011100	0.000000000
.024441900	.008549830	.027468300	.006856610	.006856610	.027468300
.008549830	.024441900	0.000000000	.016667800	.012920900	.019210600
.006856610	.018225100	.018225100	.006856610	.019210600	.012920900
.016667800	0.000000000	.042831100	.042831100	0.000000000	.055238700
.034951700	.034951700	.055238700	0.000000000	.042831100	.034951700
.039195600	.039195600	.034951700	.042831100		

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TABLE 2-3

(Sheet 9 of 22)

124 ANGLES 1,17.5,49 DEGREES ON A LEVEL
109 ANGLES IN THE +ETA DIRECTION, 15 ANGLES IN THE -ETA DIRECTION

7U

-.361249000	-.238619000	.238619000	-.750201000	-.661209000	-.238619000
.238619000	.661209000	-.971113000	-.932470000	-.661209000	-.238619000
.238619000	.661209000	.932470000	-.024917777	-.024913982	-.023764506
-.012458888	.012458888	.023764506	.024913982	-.057171433	-.057162725
-.054525365	-.028585716	.028585716	.054525365	.057162725	-.089555393
-.089541753	-.085410496	-.044777696	.044777696	.085410496	.089541753
-.121887680	-.121869116	-.116246347	-.060943840	.060943840	.116246347
.121869116	-.154107249	-.154083777	-.146974695	-.077053624	.077053624
.146974695	.154083777	-.186171501	-.186143147	-.177554917	-.093085751
.093085751	.177554917	.186143147	-.218042951	-.218009742	-.207951259
-.109021476	.109021476	.207951259	.218009742	-.249686111	-.249648083
-.238129877	-.124843056	.124843056	.238129877	.249648083	-.281066512
-.281023704	-.268057897	-.140533256	.140533256	.268057897	.281023704
-.312150340	-.312102798	-.297703070	-.156075170	.156075170	.297703070
.312102798	-.342904308	-.342852082	-.327033651	-.171452154	.171452154
.327033651	.342852082	-.501663000	-.433395000	-.148874000	.148874000
.433395000	-.733759000	-.679410000	-.433395000	-.148874000	.148874000
.433395000	.679410000	-.901204000	-.865063000	-.679410000	-.433395000
-.148874000	.148874000	.433395000	.679410000	.865063000	-.988856000
-.973907000	-.865063000	-.679410000	-.433395000	-.148874000	.148874000
.433395000	.679410000	.865063000	.973907000		
-.932470000	-.932470000	-.932470000	-.661209000	-.661209000	-.661209000
-.661209000	-.661209000	-.238619000	-.238619000	-.238619000	-.238619000
-.238619000	-.238619000	-.238619000	.999689504	.999689504	.999689504
.999689504	.999689504	.999689504	.999689504	.998364376	.998364376
.998364376	.998364376	.998364376	.998364376	.998364376	.995981843
.995981843	.995981843	.995981843	.995981843	.995981843	.995981843
.992543900	.992543900	.992543900	.992543900	.992543900	.992543900
.992543900	.988054126	.988054126	.988054126	.988054126	.988054126
.988054126	.988054126	.982517263	.982517263	.982517263	.982517263
.982517263	.982517263	.982517263	.975939174	.975939174	.975939174
.975939174	.975939174	.975939174	.975939174	.968326828	.968326828
.968326828	.968326828	.968326828	.968326828	.968326828	.959688291
.959688291	.959688291	.959688291	.959688291	.959688291	.959688291
.950032718	.950032718	.950032718	.950032718	.950032718	.950032718
.950032718	.939370340	.939370340	.939370340	.939370340	.939370340
.939370340	.939370340	.865063000	.865063000	.865063000	.865063000
.865063000	.679410000	.679410000	.679410000	.679410000	.679410000
.679410000	.679410000	.433395000	.433395000	.433395000	.433395000
.433395000	.433395000	.433395000	.433395000	.433395000	.148874000
.148874000	.148874000	.148874000	.148874000	.148874000	.148874000
.148874000	.148874000	.148874000	.148874000		

TABLE 2-3

(Sheet 10 of 22)

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6U

0.000000000	.042831100	.042831100	0.000000000	.055238700	.034951700
.034951700	.055238700	0.000000000	.042831100	.034951700	.039195600
.039195600	.034951700	.042831100	0.000000000	.000004427	.000061973
.000132799	.000132799	.000061973	.000004427	0.000000000	.000010300
.000144197	.000308994	.000308994	.000144197	.000010300	0.000000000
.000016171	.000226390	.000485122	.000485122	.000226390	.000016171
0.000000000	.000022025	.000308354	.000660759	.000660759	.000308354
.000022025	0.000000000	.000027857	.000389994	.000835700	.000835700
.000389994	.000027857	0.000000000	.000033659	.000471220	.001009758
.001009758	.000471220	.000033659	0.000000000	.000039425	.000551948
.001182745	.001182745	.000551948	.000039425	0.000000000	.000045149
.000632090	.001354479	.001354479	.000632090	.000045149	0.000000000
.000050826	.000711563	.001524778	.001524778	.000711563	.000050826
0.000000000	.000056449	.000790282	.001693462	.001693462	.000790282
.000056449	0.000000000	.000064109	.000897526	.001923271	.001923271
.000897526	.000064109	0.000000000	.024441900	.012920900	.012920900
.024441900	0.000000000	.027011100	.008549830	.019210600	.019210600
.008549830	.027011100	0.000000000	.024441900	.008549830	.027468300
.006856610	.006856610	.027468300	.008549830	.024441900	0.000000000
.016667800	.012920900	.019210600	.006856610	.018225100	.018225100
.006856610	.019210600	.012920900	.016667800		

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TABLE 2-3

(Sheet 11 of 22)

124 ANGLES 2.5,17.5,49 DEGREES ON A LEVEL
15 ANGLES IN THE +ETA DIRECTION, 109 ANGLES IN THE -ETA DIRECTION

7U

-.024917777	-.024894060	-.023764506	-.012458888	.012458888	.023764506
.024894060	-.057171433	-.057117018	-.054525365	-.028585716	.028585716
.054525365	.057117018	-.089555393	-.089470156	-.085410496	-.044777696
.044777696	.085410496	.089470156	-.121887680	-.121771670	-.116246347
-.060943840	.060943840	.116246347	.121771670	-.154107249	-.153960573
-.146974695	-.077053624	.077053624	.146974695	.153960573	-.186171501
-.185994307	-.177554917	-.093085751	.093085751	.177554917	.185994307
-.218042951	-.217835423	-.207951259	-.109021476	.109021476	.207951259
.217835423	-.249686111	-.249448465	-.238129877	-.124843056	.124843056
.238129877	.249448465	-.281066512	-.280798999	-.268057897	-.140533256
.140533256	.268057897	.280798999	-.312150340	-.311853242	-.297703070
-.156075170	.156075170	.297703070	.311853242	-.342904308	-.342577939
-.327033651	-.171452154	.171452154	.327033651	.342577939	-.501663000
-.433395000	-.148874000	.148874000	.433395000	-.733759000	-.679410000
-.433395000	-.148874000	.148874000	.433395000	.679410000	-.901204000
-.865063000	-.679410000	-.433395000	-.148874000	.148874000	.433395000
.679410000	.865063000	-.988856000	-.973907000	-.865063000	-.679410000
-.433395000	-.148874000	.148874000	.433395000	.679410000	.865063000
.973907000	-.361249000	-.238619000	.238619000	-.750201000	-.661209000
-.238619000	.238619000	.661209000	-.971113000	-.932470000	-.661209000
-.238619000	.238619000	.661209000	.932470000		
-.999689504	-.999689504	-.999689504	-.999689504	-.999689504	-.999689504
-.999689504	-.998364376	-.998364376	-.998364376	-.998364376	-.998364376
-.998364376	-.998364376	-.995981843	-.995981843	-.995981843	-.995981843
-.995981843	-.995981843	-.995981843	-.992543900	-.992543900	-.992543900
-.992543900	-.992543900	-.992543900	-.992543900	-.988054126	-.988054126
-.988054126	-.988054126	-.988054126	-.988054126	-.988054126	-.982517263
-.982517263	-.982517263	-.982517263	-.982517263	-.982517263	-.982517263
-.975939174	-.975939174	-.975939174	-.975939174	-.975939174	-.975939174
-.975939174	-.968326828	-.968326828	-.968326828	-.968326828	-.968326828
-.968326828	-.968326828	-.959688291	-.959688291	-.959688291	-.959688291
-.959688291	-.959688291	-.959688291	-.950032718	-.950032718	-.950032718
-.950032718	-.950032718	-.950032718	-.950032718	-.939370340	-.939370340
-.939370340	-.939370340	-.939370340	-.939370340	-.939370340	-.865063000
-.865063000	-.865063000	-.865063000	-.865063000	-.679410000	-.679410000
-.679410000	-.679410000	-.679410000	-.679410000	-.679410000	-.433395000
-.433395000	-.433395000	-.433395000	-.433395000	-.433395000	-.433395000
-.433395000	-.433395000	-.148874000	-.148874000	-.148874000	-.148874000
-.148874000	-.148874000	-.148874000	-.148874000	-.148874000	-.148874000
-.148874000	.932470000	.932470000	.932470000	.661209000	.661209000
.661209000	.661209000	.661209000	.238619000	.238619000	.238619000
.238619000	.238619000	.238619000	.238619000		

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0.000000000	.000011067	.000055333	.000132799	.000132799	.000055333
.000011067	0.000000000	.000025749	.000128747	.000308994	.000308994
.000128747	.000025749	0.000000000	.000040427	.000202134	.000485122
.000485122	.000202134	.000040427	0.000000000	.000055063	.000275316
.000660759	.000660759	.000275316	.000055063	0.000000000	.000069642
.000348209	.000835700	.000835700	.000348209	.000069642	0.000000000
.000084146	.000420732	.001009758	.001009758	.000420732	.000084146
0.000000000	.000098562	.000492810	.001182745	.001182745	.000492810
.000098562	0.000000000	.000112873	.000564366	.001354479	.001354479
.000564366	.000112873	0.000000000	.000127065	.000635324	.001524778
.001524778	.000635324	.000127065	0.000000000	.000141122	.000705609
.001693462	.001693462	.000705609	.000141122	0.000000000	.000160273
.000801363	.001923271	.001923271	.000801363	.000160273	0.000000000
.024441900	.012920900	.012920900	.024441900	0.000000000	.027011100

.008549830	.019210600	.019210600	.008549830	.027011100	0.000000000
.024441900	.008549830	.027468300	.006856610	.006856610	.027468300
.008549830	.024441900	0.000000000	.016667800	.012920900	.019210600
.006856610	.018225100	.018225100	.006856610	.019210600	.012920900
.016667800	0.000000000	.042831100	.042831100	0.000000000	.055238700
.034951700	.034951700	.055238700	0.000000000	.042831100	.034951700
.039195600	.039195600	.034951700	.042831100		

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TABLE 2-3

(Sheet 13 of 22)

124 ANGLES 2.5,17.5,49 DEGREES ON A LEVEL
109 ANGLES IN THE +ETA DIRECTION, 15 ANGLES IN THE -ETA DIRECTION

7U

-.361249000	-.238619000	.238619000	-.750201000	-.661209000	-.238619000
.238619000	.661209000	-.971113000	-.932470000	-.661209000	-.238619000
.238619000	.661209000	.932470000	-.024917777	-.024894060	-.023764506
-.012458888	.012458888	.023764506	.024894060	-.057171433	-.057117018
-.054525365	-.028585716	.028585716	.054525365	.057117018	-.089555393
-.089470156	-.085410496	-.044777696	.044777696	.085410496	.089470156
-.121887680	-.121771670	-.116246347	-.060943840	.060943840	.116246347
.121771670	-.154107249	-.153960573	-.146974695	-.077053624	.077053624
.146974695	.153960573	-.186171501	-.185994307	-.177554917	-.093085751
.093085751	.177554917	.185994307	-.218042951	-.217835423	-.207951259
-.109021476	.109021476	.207951259	.217835423	-.249686111	-.249448465
-.238129877	-.124843056	.124843056	.238129877	.249448465	-.281066512
-.280798999	-.268057897	-.140533256	.140533256	.268057897	.280798999
-.312150340	-.311853242	-.297703070	-.156075170	.156075170	.297703070
.311853242	-.342904308	-.342577939	-.327033651	-.171452154	.171452154
.327033651	.342577939	-.501663000	-.433395000	-.148874000	.148874000
.433395000	-.733759000	-.679410000	-.433395000	-.148874000	.148874000
.433395000	.679410000	-.901204000	-.865063000	-.679410000	-.433395000
-.148874000	.148874000	.433395000	.679410000	.865063000	-.988856000
-.973907000	-.865063000	-.679410000	-.433395000	-.148874000	.148874000
.433395000	.679410000	.865063000	.973907000		
-.932470000	-.932470000	-.932470000	-.661209000	-.661209000	-.661209000
-.661209000	-.661209000	-.238619000	-.238619000	-.238619000	-.238619000
-.238619000	-.238619000	-.238619000	.999689504	.999689504	.999689504
.999689504	.999689504	.999689504	.999689504	.998364376	.998364376
.998364376	.998364376	.998364376	.998364376	.998364376	.995981843
.995981843	.995981843	.995981843	.995981843	.995981843	.995981843
.992543900	.992543900	.992543900	.992543900	.992543900	.992543900
.992543900	.988054126	.988054126	.988054126	.988054126	.988054126
.988054126	.988054126	.982517263	.982517263	.982517263	.982517263
.982517263	.982517263	.982517263	.975939174	.975939174	.975939174
.975939174	.975939174	.975939174	.975939174	.968326828	.968326828
.968326828	.968326828	.968326828	.968326828	.968326828	.959688291
.959688291	.959688291	.959688291	.959688291	.959688291	.959688291
.950032718	.950032718	.950032718	.950032718	.950032718	.950032718
.950032718	.939370340	.939370340	.939370340	.939370340	.939370340
.939370340	.939370340	.865063000	.865063000	.865063000	.865063000
.865063000	.679410000	.679410000	.679410000	.679410000	.679410000
.679410000	.679410000	.433395000	.433395000	.433395000	.433395000
.433395000	.433395000	.433395000	.433395000	.433395000	.148874000
.148874000	.148874000	.148874000	.148874000	.148874000	.148874000
.148874000	.148874000	.148874000	.148874000		

TABLE 2-3

(Sheet 14 of 22)

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0.000000000	.042831100	.042831100	0.000000000	.055238700	.034951700
.034951700	.055238700	0.000000000	.042831100	.034951700	.039195600
.039195600	.034951700	.042831100	0.000000000	.000011067	.000055333
.000132799	.000132799	.000055333	.000011067	0.000000000	.000025749
.000128747	.000308994	.000308994	.000128747	.000025749	0.000000000
.000040427	.000202134	.000485122	.000485122	.000202134	.000040427
0.000000000	.000055063	.000275316	.000660759	.000660759	.000275316
.000055063	0.000000000	.000069642	.000348209	.000835700	.000835700
.000348209	.000069642	0.000000000	.000084146	.000420732	.001009758
.001009758	.000420732	.000084146	0.000000000	.000098562	.000492810
.001182745	.001182745	.000492810	.000098562	0.000000000	.000112873
.000564366	.001354479	.001354479	.000564366	.000112873	0.000000000
.000127065	.000635324	.001524778	.001524778	.000635324	.000127065
0.000000000	.000141122	.000705609	.001693462	.001693462	.000705609

.000141122	0.000000000	.000160273	.000801363	.001923271	.001923271
.000801363	.000160273	0.000000000	.024441900	.012920900	.012920900
.024441900	0.000000000	.027011100	.008549830	.019210600	.019210600
.008549830	.027011100	0.000000000	.024441900	.008549830	.027468300
.006856610	.006856610	.027468300	.008549830	.024441900	0.000000000
.016667800	.012920900	.019210600	.006856610	.018225100	.018225100
.006856610	.019210600	.012920900	.016667800		

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TABLE 2-3

(Sheet 15 of 22)

138 ANGLES 1,17.5,49 DEGREES ON A LEVEL
15 ANGLES IN THE +ETA DIRECTION, 123 ANGLES IN THE -ETA DIRECTION

7U

-.002399998	-.002399633	-.002288919	-.001199999	.001199999	.002288919
.002399633	-.009599889	-.009598427	-.009155577	-.004799945	.004799945
.009155577	.009598427	-.027196749	-.027192607	-.025938001	-.013598375
.013598375	.025938001	.027192607	-.057171433	-.057162725	-.054525365
-.028585716	.028585716	.054525365	.057162725	-.089555393	-.089541753
-.085410496	-.044777696	.044777696	.085410496	.089541753	-.121887680
-.121869116	-.116246347	-.060943840	.060943840	.116246347	.121869116
-.154107249	-.154083777	-.146974695	-.077053624	.077053624	.146974695
.154083777	-.186171501	-.186143147	-.177554917	-.093085751	.093085751
.177554917	.186143147	-.218042951	-.218009742	-.207951259	-.109021476
.109021476	.207951259	.218009742	-.249686111	-.249648083	-.238129877
-.124843056	.124843056	.238129877	.249648083	-.281066512	-.281023704
-.268057897	-.140533256	.140533256	.268057897	.281023704	-.312150340
-.312102798	-.297703070	-.156075170	.156075170	.297703070	.312102798
-.342904308	-.342852082	-.327033651	-.171452154	.171452154	.327033651
.342852082	-.501663000	-.433395000	-.148874000	.148874000	.433395000
-.733759000	-.679410000	-.433395000	-.148874000	.148874000	.433395000
.679410000	-.901204000	-.865063000	-.679410000	-.433395000	-.148874000
.148874000	.433395000	.679410000	.865063000	-.988856000	-.973907000
-.865063000	-.679410000	-.433395000	-.148874000	.148874000	.433395000
.679410000	.865063000	.973907000	-.361249000	-.238619000	.238619000
-.750201000	-.661209000	-.238619000	.238619000	.661209000	-.971113000
-.932470000	-.661209000	-.238619000	.238619000	.661209000	.932470000
-.999997120	-.999997120	-.999997120	-.999997120	-.999997120	-.999997120
-.999997120	-.999953920	-.999953920	-.999953920	-.999953920	-.999953920
-.999953920	-.999953920	-.999630100	-.999630100	-.999630100	-.999630100
-.999630100	-.999630100	-.999630100	-.998364376	-.998364376	-.998364376
-.998364376	-.998364376	-.998364376	-.998364376	-.995981843	-.995981843
-.995981843	-.995981843	-.995981843	-.995981843	-.995981843	-.992543900
-.992543900	-.992543900	-.992543900	-.992543900	-.992543900	-.992543900
-.988054126	-.988054126	-.988054126	-.988054126	-.988054126	-.988054126
-.988054126	-.982517263	-.982517263	-.982517263	-.982517263	-.982517263
-.982517263	-.982517263	-.975939174	-.975939174	-.975939174	-.975939174
-.975939174	-.975939174	-.975939174	-.968326828	-.968326828	-.968326828
-.968326828	-.968326828	-.968326828	-.968326828	-.959688291	-.959688291
-.959688291	-.959688291	-.959688291	-.959688291	-.959688291	-.950032718
-.950032718	-.950032718	-.950032718	-.950032718	-.950032718	-.950032718
-.939370340	-.939370340	-.939370340	-.939370340	-.939370340	-.939370340
-.939370340	-.865063000	-.865063000	-.865063000	-.865063000	-.865063000
-.679410000	-.679410000	-.679410000	-.679410000	-.679410000	-.679410000
-.679410000	-.433395000	-.433395000	-.433395000	-.433395000	-.433395000
-.433395000	-.433395000	-.433395000	-.433395000	-.148874000	-.148874000
-.148874000	-.148874000	-.148874000	-.148874000	-.148874000	-.148874000
-.148874000	-.148874000	-.148874000	.932470000	.932470000	.932470000
.661209000	.661209000	.661209000	.661209000	.661209000	.238619000
.238619000	.238619000	.238619000	.238619000	.238619000	.238619000

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0.000000000	.000000064	.000000896	.000001920	.000001920	.000000896
.000000064	0.000000000	.000000512	.000007168	.000015360	.000015360
.000007168	.000000512	0.000000000	.000003851	.000053909	.000115519
.000115519	.000053909	.000003851	0.000000000	.000010300	.000144197
.000306994	.000308994	.000144197	.000010300	0.000000000	.000016171
.000226390	.000485122	.000485122	.000226390	.000016171	0.000000000
.000022025	.000308354	.000660759	.000660759	.000308354	.000022025
0.000000000	.000027857	.000389994	.000835700	.000835700	.000389994
.000027857	0.000000000	.000033659	.000471220	.001009758	.001009758
.000471220	.000033659	0.000000000	.000039425	.000551948	.001182745

.001182745	.000551948	.000039425	0.000000000	.000045149	.000632090
.001354479	.001354479	.000632090	.000045149	0.000000000	.000050826
.000711563	.001524778	.001524778	.000711563	.000050826	0.000000000
.000056449	.000790282	.001693462	.001693462	.000790282	.000056449
0.000000000	.000064109	.000897526	.001923271	.001923271	.000897526
.000064109	0.000000000	.024441900	.012920900	.012920900	.024441900
0.000000000	.027011100	.008549830	.019210600	.019210600	.008549830
.027011100	0.000000000	.024441900	.008549830	.027468300	.006856610
.006856610	.027468300	.008549830	.024441900	0.000000000	.016667800
.012920900	.019210600	.006856610	.018225100	.018225100	.006856610
.019210600	.012920900	.016667800	0.000000000	.042831100	.042831100
0.000000000	.055238700	.034951700	.034951700	.055238700	0.000000000
.042831100	.034951700	.039195600	.039195600	.034951700	.042831100

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TABLE 2-3

(Sheet 17 of 22)

138 ANGLES 1,17.5,49 DEGREES ON A LEVEL
123 ANGLES IN THE +ETA DIRECTION, 15 ANGLES IN THE -ETA DIRECTION

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-.361249000	-.238619000	.238619000	-.750201000	-.661209000	-.238619000
.238619000	.661209000	-.971113000	-.932470000	-.661209000	-.238619000
.238619000	.661209000	.932470000	-.002399998	-.002399633	-.002288919
-.001199999	.001199999	.002288919	.002399633	-.009599889	-.009598427
-.009155577	-.004799945	.004799945	.009155577	.009598427	-.027196749
-.027192607	-.025938001	-.013598375	.013598375	.025938001	.027192607
-.057171433	-.057162725	-.054525365	-.028585716	.028585716	.054525365
.057162725	-.089555393	-.089541753	-.085410496	-.044777696	.044777696
.085410496	.089541753	-.121887680	-.121869116	-.116246347	-.060943840
.060943840	.116246347	.121869116	-.154107249	-.154083777	-.146974695
-.077053624	.077053624	.146974695	.154083777	-.186171501	-.186143147
-.177554917	-.093085751	.093085751	.177554917	.186143147	-.218042951
-.218009742	-.207951259	-.109021476	.109021476	.207951259	.218009742
-.249686111	-.249648083	-.238129877	-.124843056	.124843056	.238129877
.249648083	-.281066512	-.281023704	-.268057897	-.140533256	.140533256
.268057897	.281023704	-.312150340	-.312102798	-.297703070	-.156075170
.156075170	.297703070	.312102798	-.342904308	-.342852082	-.327033651
-.171452154	.171452154	.327033651	.342852082	-.501663000	-.433395000
-.148874000	.148874000	.433395000	-.733759000	-.679410000	-.433395000
-.148874000	.148874000	.433395000	.679410000	-.901204000	-.865063000
-.679410000	-.433395000	-.148874000	.148874000	.433395000	.679410000
.865063000	-.988856000	-.973907000	-.865063000	-.679410000	-.433395000
-.148874000	.148874000	.433395000	.679410000	.865063000	.973907000
-.932470000	-.932470000	-.932470000	-.661209000	-.661209000	-.661209000
-.661209000	-.661209000	-.238619000	-.238619000	-.238619000	-.238619000
-.238619000	-.238619000	-.238619000	.999997120	.999997120	.999997120
.999997120	.999997120	.999997120	.999997120	.999953920	.999953920
.999953920	.999953920	.999953920	.999953920	.999953920	.999630100
.999630100	.999630100	.999630100	.999630100	.999630100	.999630100
.998364376	.998364376	.998364376	.998364376	.998364376	.998364376
.998364376	.995981843	.995981843	.995981843	.995981843	.995981843
.995981843	.995981843	.992543900	.992543900	.992543900	.992543900
.992543900	.992543900	.992543900	.988054126	.988054126	.988054126
.988054126	.988054126	.988054126	.988054126	.982517263	.982517263
.982517263	.982517263	.982517263	.982517263	.982517263	.975939174
.975939174	.975939174	.975939174	.975939174	.975939174	.975939174
.968326828	.968326828	.968326828	.968326828	.968326828	.968326828
.968326828	.959688291	.959688291	.959688291	.959688291	.959688291
.959688291	.959688291	.950032718	.950032718	.950032718	.950032718
.950032718	.950032718	.950032718	.939370340	.939370340	.939370340
.939370340	.939370340	.939370340	.939370340	.865063000	.865063000
.865063000	.865063000	.865063000	.679410000	.679410000	.679410000
.679410000	.679410000	.679410000	.679410000	.433395000	.433395000
.433395000	.433395000	.433395000	.433395000	.433395000	.433395000
.433395000	.148874000	.148874000	.148874000	.148874000	.148874000
.148874000	.148874000	.148874000	.148874000	.148874000	.148874000

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0.000000000	.042831100	.042831100	0.000000000	.055238700	.034951700
.034951700	.055238700	0.000000000	.042831100	.034951700	.039195600
.039195600	.034951700	.042831100	0.000000000	.000000064	.000000896
.000001920	.000001920	.000000896	.000000064	0.000000000	.000000512
.000007168	.000015360	.000015360	.000007168	.000000512	0.000000000
.000003851	.000053909	.000115519	.000115519	.000053909	.000003851
0.000000000	.000010300	.000144197	.000308994	.000308994	.000144197
.000010300	0.000000000	.000016171	.000226390	.000485122	.000485122
.000226390	.000016171	0.000000000	.000022025	.000308354	.000660759
.000660759	.000308354	.000022025	0.000000000	.000027857	.000389994

.000835700	.000835700	.000389994	.000027857	0.000000000	.000033659
.000471220	.001009758	.001009758	.000471220	.000033659	0.000000000
.000039425	.000551948	.001182745	.001182745	.000551948	.000039425
0.000000000	.000045149	.000632090	.001354479	.001354479	.000632090
.000045149	0.000000000	.000050826	.000711563	.001524778	.001524778
.000711563	.000050826	0.000000000	.000056449	.000790282	.001693462
.001693462	.000790282	.000056449	0.000000000	.000064109	.000897526
.001923271	.001923271	.000897526	.000064109	0.000000000	.024441900
.012920900	.012920900	.024441900	0.000000000	.027011100	.008549830
.019210600	.019210600	.008549830	.027011100	0.000000000	.024441900
.008549830	.027468300	.006856610	.006856610	.027468300	.008549830
.024441900	0.000000000	.016667800	.012920900	.019210600	.006856610
.018225100	.018225100	.006856610	.019210600	.012920900	.016667800

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TABLE 2-3

(Sheet 19 of 22)

146 ANGLES 1,6,30,70 DEGREES ON A LEVEL
15 ANGLES IN THE +ETA DIRECTION, 131 ANGLES IN THE -ETA DIRECTION

7U

-.024917777	-.024913982	-.024781274	-.021579428	-.008522382	.008522382
.021579428	.024781274	.024913982	-.057171433	-.057162725	-.056858242
-.049511913	-.019553782	.019553782	.049511913	.056858242	.057162725
-.089555393	-.089541753	-.089064799	-.077557245	-.030629748	.030629748
.077557245	.089064799	.089541753	-.121887680	-.121869116	-.121219967
-.105557827	-.041688042	.041688042	.105557827	.121219967	.121869116
-.154107249	-.154083777	-.153263033	-.133460792	-.052707783	.052707783
.133460792	.153263033	.154083777	-.186171501	-.186143147	-.185151634
-.161229250	-.063674404	.063674404	.161229250	.185151634	.186143147
-.218042951	-.218009742	-.216848489	-.188830735	-.074575081	.074575081
.188830735	.216848489	.218009742	-.249686111	-.249648083	-.248318305
-.216234515	-.085397680	.085397680	.216234515	.248318305	.249648083
-.281066512	-.281023704	-.279526800	-.243410739	-.096130409	.096130409
.243410739	.279526800	.281023704	-.312150340	-.312102798	-.310440348
-.270330124	-.106761704	.106761704	.270330124	.310440348	.312102798
-.342904308	-.342852082	-.341025842	-.296963842	-.117280181	.117280181
.296963842	.341025842	.342852082	-.501663000	-.433395000	-.148874000
.148874000	.433395000	-.733759000	-.679410000	-.433395000	-.148874000
.148874000	.433395000	.679410000	-.901204000	-.865063000	-.679410000
-.433395000	-.148874000	.148874000	.433395000	.679410000	.865063000
-.988856000	-.973907000	-.865063000	-.679410000	-.433395000	-.148874000
.148874000	.433395000	.679410000	.865063000	.973907000	-.361249000
-.238619000	.238619000	-.750201000	-.661209000	-.238619000	.238619000
.661209000	-.971113000	-.932470000	-.661209000	-.238619000	.238619000
.661209000	.932470000				
-.999689504	-.999689504	-.999689504	-.999689504	-.999689504	-.999689504
-.999689504	-.999689504	-.999689504	-.998364376	-.998364376	-.998364376
-.998364376	-.998364376	-.998364376	-.998364376	-.998364376	-.998364376
-.995981843	-.995981843	-.995981843	-.995981843	-.995981843	-.995981843
-.995981843	-.995981843	-.995981843	-.992543900	-.992543900	-.992543900
-.992543900	-.992543900	-.992543900	-.992543900	-.992543900	-.992543900
-.988054126	-.988054126	-.988054126	-.988054126	-.988054126	-.988054126
-.988054126	-.988054126	-.988054126	-.982517263	-.982517263	-.982517263
-.982517263	-.982517263	-.982517263	-.982517263	-.982517263	-.982517263
-.975939174	-.975939174	-.975939174	-.975939174	-.975939174	-.975939174
-.975939174	-.975939174	-.975939174	-.968326828	-.968326828	-.968326828
-.968326828	-.968326828	-.968326828	-.968326828	-.968326828	-.968326828
-.959688291	-.959688291	-.959688291	-.959688291	-.959688291	-.959688291
-.959688291	-.959688291	-.959688291	-.950032718	-.950032718	-.950032718
-.950032718	-.950032718	-.950032718	-.950032718	-.950032718	-.950032718
-.939370340	-.939370340	-.939370340	-.939370340	-.939370340	-.939370340
-.939370340	-.939370340	-.939370340	-.865063000	-.865063000	-.865063000
-.865063000	-.865063000	-.679410000	-.679410000	-.679410000	-.679410000
-.679410000	-.679410000	-.679410000	-.433395000	-.433395000	-.433395000
-.433395000	-.433395000	-.433395000	-.433395000	-.433395000	-.433395000
-.148874000	-.148874000	-.148874000	-.148874000	-.148874000	-.148874000
-.148874000	-.148874000	-.148874000	-.148874000	-.148874000	.932470000
.932470000	.932470000	.661209000	.661209000	.661209000	.661209000
.661209000	.238619000	.238619000	.238619000	.238619000	.238619000
.238619000	.238619000				

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EU

0.000000000	.000004427	.000017706	.000088532	.000088532	.000088532
.000088532	.000017706	.000004427	0.000000000	.000010300	.000041199
.000205996	.000205996	.000205996	.000205996	.000041199	.000010300
0.000000000	.000016171	.000064683	.000323415	.000323415	.000323415
.000323415	.000064683	.000016171	0.000000000	.000022025	.000088101
.000440506	.000440506	.000440506	.000440506	.000088101	.000022025

0.000000000	.000027857	.000111427	.000557134	.000557134	.000557134
.000557134	.000111427	.000027857	0.000000000	.000033659	.000134634
.000673172	.000673172	.000673172	.000673172	.000134634	.000033659
0.000000000	.000039425	.000157699	.000788497	.000788497	.000788497
.000788497	.000157699	.000039425	0.000000000	.000045149	.000180597
.000902986	.000902986	.000902986	.000902986	.000180597	.000045149
0.000000000	.000050826	.000203304	.001016519	.001016519	.001016519
.001016519	.000203304	.000050826	0.000000000	.000056449	.000225795
.001128974	.001128974	.001128974	.001128974	.000225795	.000056449
0.000000000	.000064109	.000256436	.001282180	.001282180	.001282180
.001282180	.000256436	.000064109	0.000000000	.024441900	.012920900
.012920900	.024441900	0.000000000	.027011100	.008549830	.019210600
.019210600	.008549830	.027011100	0.000000000	.024441900	.008549830
.027468300	.006856610	.006856610	.027468300	.008549830	.024441900
0.000000000	.016667800	.012920900	.019210600	.006856610	.018225100
.018225100	.006856610	.019210600	.012920900	.016667800	0.000000000
.042831100	.042831100	0.000000000	.055238700	.034951700	.034951700
.055238700	0.000000000	.042831100	.034951700	.039195600	.039195600
.034951700	.042831100				

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TABLE 2-3

(Sheet 21 of 22)

146 ANGLES 1,6,30,70. DEGREES ON A LEVEL
131-ANGLES IN THE +ETA DIRECTION, 15 ANGLES IN THE -ETA DIRECTION

7U

-.361249000	-.238619000	.238619000	-.750201000	-.661209000	-.238619000
.238619000	.661209000	-.971113000	-.932470000	-.661209000	-.238619000
.238619000	.661209000	.932470000	-.024917777	-.024913982	-.024781274
-.021579428	-.008522382	.008522382	.021579428	.024781274	.024913982
-.057171433	-.057162725	-.056858242	-.049511913	-.019553782	.019553782
.049511913	.056858242	.057162725	-.089555393	-.089541753	-.089064799
-.077557245	-.030629748	.030629748	.077557245	.089064799	.089541753
-.121897680	-.121869116	-.121219967	-.105557827	-.041688042	.041688042
.105557827	.121219967	.121869116	-.154107249	-.154083777	-.153263033
-.133460792	-.052707783	.052707783	.133460792	.153263033	.154083777
-.186171501	-.186143147	-.185151634	-.161229250	-.063674404	.063674404
.161229250	.185151634	.186143147	-.218042951	-.218009742	-.216848489
-.188830735	-.074575081	.074575081	.188830735	.216848489	.218009742
-.249686111	-.249648083	-.248318305	-.216234515	-.085397680	.085397680
.216234515	.248318305	.249648083	-.281066512	-.281023704	-.279526800
-.243410739	-.096130409	.096130409	.243410739	.279526800	.281023704
-.312150340	-.312102798	-.310440348	-.270330124	-.106761704	.106761704
.270330124	.310440348	.312102798	-.342904308	-.342852082	-.341025842
-.296963842	-.117280181	.117280181	.296963842	.341025842	.342852082
-.501663000	-.433395000	-.148874000	.148874000	.433395000	-.733759000
-.679410000	-.433395000	-.148874000	.148874000	.433395000	.679410000
-.901204000	-.865063000	-.679410000	-.433395000	-.148874000	.148874000
.433395000	.679410000	.865063000	-.988856000	-.973907000	-.865063000
-.679410000	-.433395000	-.148874000	.148874000	.433395000	.679410000
.865063000	.973907000				
-.932470000	-.932470000	-.932470000	-.661209000	-.661209000	-.661209000
-.661209000	-.661209000	-.238619000	-.238619000	-.238619000	-.238619000
-.238619000	-.238619000	-.238619000	.999689504	.999689504	.999689504
.999689504	.999689504	.999689504	.999689504	.999689504	.999689504
.998364376	.998364376	.998364376	.998364376	.998364376	.998364376
.998364376	.998364376	.998364376	.995981843	.995981843	.995981843
.995981843	.995981843	.995981843	.995981843	.995981843	.995981843
.992543900	.992543900	.992543900	.992543900	.992543900	.992543900
.992543900	.992543900	.992543900	.988054126	.988054126	.988054126
.988054126	.988054126	.988054126	.988054126	.988054126	.988054126
.982517263	.982517263	.982517263	.982517263	.982517263	.982517263
.982517263	.982517263	.982517263	.975939174	.975939174	.975939174
.975939174	.975939174	.975939174	.975939174	.975939174	.975939174
.968326828	.968326828	.968326828	.968326828	.968326828	.968326828
.968326828	.968326828	.968326828	.959688291	.959688291	.959688291
.959688291	.959688291	.959688291	.959688291	.959688291	.959688291
.950032718	.950032718	.950032718	.950032718	.950032718	.950032718
.950032718	.950032718	.950032718	.939370340	.939370340	.939370340
.939370340	.939370340	.939370340	.939370340	.939370340	.939370340
.865063000	.865063000	.865063000	.865063000	.865063000	.679410000
.679410000	.679410000	.679410000	.679410000	.679410000	.679410000
.433395000	.433395000	.433395000	.433395000	.433395000	.433395000
.433395000	.433395000	.433395000	.148874000	.148874000	.148874000
.148874000	.148874000	.148874000	.148874000	.148874000	.148874000
.148874000	.148874000				

TABLE 2-3

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6U

0.000000000	.042831100	.042831100	0.000000000	.055238700	.034951700
.034951700	.055238700	0.000000000	.042831100	.034951700	.039195600
.039195600	.034951700	.042831100	0.000000000	.000004427	.000017706
.000089532	.000088532	.000088532	.000088532	.000017706	.000004427
0.000000000	.000010300	.000041199	.000205996	.000205996	.000205996
.000205996	.000041199	.000010300	0.000000000	.000016171	.000064683

.000323415	.000323415	.000323415	.000323415	.000064683	.000016171
0.000000000	.000022025	.000088101	.000440506	.000440506	.000440506
.000440506	.000088101	.000022025	0.000000000	.000027857	.000111427
.000557134	.000557134	.000557134	.000557134	.000111427	.000027857
0.000000000	.000033659	.000134634	.000673172	.000673172	.000673172
.000673172	.000134634	.000033659	0.000000000	.000039425	.000157699
.000788497	.000788497	.000788497	.000788497	.000157699	.000039425
0.000000000	.000045149	.000180597	.000902986	.000902986	.000902986
.000902986	.000180597	.000045149	0.000000000	.000050826	.000203304
.001016519	.001016519	.001016519	.001016519	.000203304	.000050826
0.000000000	.000056449	.000225795	.001128974	.001128974	.001128974
.001128974	.000225795	.000056449	0.000000000	.000064109	.000256436
.001282180	.001282180	.001282180	.001282180	.000256436	.000064109
0.000000000	.024441900	.012920900	.012920900	.024441900	0.000000000
.027011100	.008549830	.019210600	.019210600	.008549830	.027011100
0.000000000	.024441900	.008549830	.027468300	.006856610	.006856610
.027468300	.008549830	.024441900	0.000000000	.016667800	.012920900
.019210600	.006856610	.018225100	.018225100	.006856610	.019210600
.012920900	.016667800				

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TABLE 2-4

QUADRATURE DATA SET PARAMETERS

Symmetric Quadrature Sets

Number of Space Angles (A04)	Number of Quadrature Angles in the upward (+η) direction (A05)	Number of Quadrature Angles in the downward (-η) direction (A06)	Number of Initialization directions in the upward (+η) direction (A07)	Number of Initialization directions in the downward (-η) direction (A08)
6 (S_2)	3	3	1	1
16 (S_4)	8	8	2	2
30 (S_6)	15	15	3	3
48 (S_8)	24	24	4	4
96 (S_{12})	48	48	6	6
160 (S_{16})	80	80	8	8

Asymmetric Quadrature Sets

80 (-η asymmetry)	15	65	3	15
80 (+η asymmetry)	65	15	15	3
102 (-η asymmetry)	15	87	3	15
102 (+η asymmetry)	87	15	15	3
124 (-η asymmetry)	15	109	3	15
124 (+η asymmetry)	109	15	15	3
138 (-η asymmetry)	15	123	3	17
138 (+η asymmetry)	123	15	17	3
146 (-η asymmetry)	15	131	3	15
146 (+η asymmetry)	131	15	15	3

The radial mesh interval spacing is approximated by the following relationship:

Criterion 1: $$\Delta R \leq \frac{1.0 + \Sigma^{S_0}_{g-g} / \Sigma^{t}_{g}}{4 \Sigma^{t}_{g}}$$

where: Σ^{t}_{g} is the largest total or transport corrected group cross section in a region for any group

$\Sigma^{S_0}_{g-g}$ is the corresponding within group scattering cross section for the above selected group.

This criteron has been relaxed somewhat from the original equation(7) because of the negative flux fixup routine normally used in DOT-IIW calculations (MODE = 1).

The axial mesh interval size is approximated by the following relationship:

Criterion 2: $$\Delta Z \leq 2.0 / \Sigma^{t}_{g}$$

where: Σ^{t}_{g} is the largest total or transport corrected group cross section in the region for any group.

In problems where core data storage limitations prevent adherence to the above two guidelines, an intuitive choice of mesh must be made to avoid questionable answers resulting from negative flux solutions. The following procedure should be followed:

Criterion 3: Criteria 1 and 2 should be applied near region boundaries or where large flux gradients occur.

Criterion 4: Mesh size should not vary more than a factor of two between adjacent mesh intervals (i.e., Criteria 1 and 2 can be relaxed within a region away from boundaries).

Criterion 5: The intervals near the periphery of a reflected core in r, z and r, θ problems should follow Criteria 1 and 2.

The remainder of the radial mesh in the core, reflector, etc., can be determined by Criterion 4.

Justification for usage of Criteria 3, 4, and 5 can be based on a prior knowledge that most of the particles at any point in a region are produced by sources or scattering down from higher groups rather than direct transport from neighboring points. At the periphery of a reflected reactor, this condition does not exist because of the returning thermal neutrons from the reflector; hence, Criterion 1 should be applied at the periphery of the core if negative fluxes are to be avoided.

Although negative fluxes may occur using Criteria 3, 4, and 5, the location of these negative fluxes and the relative flux level surrounding the negative flux should now have a negligible effect on the overall problem solution.

An approximation of mesh interval size in large non-control void regions (such as the void between a reactor and an external shield) may be represented by a method suggested by Putnam[(8)]". . .non-central voids should be handled by choosing mesh intervals in the void region as if a total cross section of $\sum_t = 1/\bar{r}$ existed in the region (where $\bar{r}$ is a mean radius). Where a large expanse of non-central void exists, it saves on mesh points to define several contiguous void regions with different r mesh interval sizes to permit fewer mesh intervals in the outer regions where $\bar{r}$ is larger."

Many DOT-IIW calculations have been performed using the recommendations outlined in this section, and the creditability of these criteria in determining mesh interval spacing has been shown in practice.

2.3 DETAILED INPUT DATA INFORMATION

This section presents a more detailed definition of selected parameters and arrays defined in Section 2.2.2. Examples are provided to illustrate the various ways of entering the data, or the specific manner in which the data must be input.

2.3.1 Eigenvalue Calculations

In a homogeneous (eigenvalue or k) calculation, the eigenvalue is the effective static multiplication factor, or the ratio of sources to losses in the time independent Boltzmann transport equation. In an eigenvalue calculation, the following conditions are required:

1) The sum of the fractional fission spectrum (1* array) must be non-zero and should sum to 1.0,
2) Neutron production cross sections must be included for the fissile materials, and
3) The flux guess for the mesh intervals spanning the fissile materials must be non-zero.

Because the fission source is determined by the flux computed in the previous outer iteration, more than one outer iteration must be performed to converge the fission source. In practice, approximately 5 to 10 iteration may be required to achieve outer iteration convergence (for EPS = 10^{-3}) for problems whose cross section matrix do not contain upscatter cross sections. Approximately 2 to 4 more outer iterations are normally required to converge the same problem if the cross section matrix contains upscatter cross sections. The maximum number of inner iterations per group required to achieve pointwise flux convergence can vary from 10 to 100 depending on the system under analysis. It is important to achieve flux convergence on inner iterations by using a pointwise flux convergence criteria so that, after scaling has been done on outer iterations, the number of outer iterations required for convergence will be at a minimum. In problems with upscatter, because the upscatter process assumes that the inner iteration flux calculation has converged, and because the DOT-IIW code has features that restrict the number of inner iterations, it is essential that pointwise flux convergence be achieved and that the restrictions on the number of inner iterations be used with caution.

A good flux guess is an essential requirement for an eigenvalue solution in a minimum of computer time. The best flux guess is from a similar DOT-IIW calculation where the number of mesh and energy groups are the same. Even if minor perturbations in material composition or mesh spacing occur, these data constitute a very good flux guess. If a previous DOT-IIW calculation converged flux tape is not available, the user should consider running two ANISN-W one-dimensional calculations to obtain a suitable flux guess. As an example, if an r-z DOT-IIW calculation is to be performed, the user would run a cylindrical (or radial) geometry ANISN-W calculation and a slab (or axial) geometry ANISN-W calculation. From these two ANISN-W calculations, the user can construct a suitable flux guess for DOT-IIW using the flux input parameter option, M07 = 4. This technique can save 2 to 6 outer iterations over a uniform flux guess. If no conceivable or practical way exists for obtaining a flux guess for a given DOT-IIW calculation, the user must input a uniform flux guess of 1.0 in the mesh intervals spanning the fissile materials and a 0.0 flux guess elsewhere. In k-calculations, the DOT-IIW code normalizes any flux guess that is input, so that only the flux shape or gradient is important. Additional information on convergence and normalization are given in Section 2.3.8 on "Other Useful Information".

2.3.2 Fixed Distributed Source Calculations

The DOT-IIW code can solve the time independent Boltzmann transport equation for inhomogeneous problems with volume distributed sources; fissions may be included for a subcritical system calculation. The two frequent types of calculations are either fixed neutron distributed source calculations with no fissions, or fixed photon distributed source calculations. For these two calculations, the following conditions apply:

1) The fractional fission spectrum (1* array) can be filled with 0.0 if no fissile materials are included,
2) If the fission spectrum (1* array) contain all 0.0s, neutron production cross sections, if present, are ignored, and
3) If no up scatter cross sections appear in the cross section matrix, only one outer iteration is required. This is accomplished by (a) making D05=0 when IAFT=1, 2,

or 3, or (b) making D05=1 when IAFT=0. If upscatter cross sections appear in the cross section matrix, then outer iteration is required to converge the upscatter source and from 3 to 10 outer iterations may be required.

If fissions are included in the volume distributed source calculation, k for the system must be less than unity for convergence (a source problem is meaningless if k>1.0). Also, convergence becomes increasingly difficult as k approaches 1.0.

It is important to achieve flux convergence on inner iterations by using a pointwise flux convergence criterion because the scattering sources for lower energy groups depend on flux solutions in the higher energy groups. The DOT-IIW code solves for the energy-dependent flux from high energy group to low energy group, and any error in the flux solution in a higher energy group tends to propagate errors in the soltuion in lower energy groups. For this reason, the maximum number of inner iterations per group required to achieve pointwise flux convergence can vary from 10 to 100 depending on the system under analysis.

A flux guess of all 0.0s is sufficient for source calculations with no fissile material. Additional information on convergence and normalization are given in Section 2.3.8 on "Other Useful Information".

2.3.3 Fixed Boundary Source Calculations

The DOT-IIW code can solve the time independent Boltzmann transport equation for inhomogeneous problems with a boundary source at the top and/or the right boundary; fissions may be included for a subcritical system calculation. The following conditions apply:

1) The fractional fission spectrum (1* array) can be filled with 0.0 if no fissile materials are included,
2) If the fission spectrum (1* array) contains all 0.0s, neutron production cross sections, if present, are ignored, and
3) If no upscatter cross sections appear in the cross section matrix, then only one outer iteration is required. This is accomplished by a) making D05=0 when IAFT= 1, 2, or 3, or b) making D05=1 when IAFT=0. If upscatter cross sections appear in the cross section matrix, then outer iteration is required to converge the upscatter source, and from 3 to 10 outer iterations may be required.

A boundary source on the right and/or top boundary is input from cards to DOT-IIW by specifying the angle, space, and group dependent boundary condition flux which results from the desired source. The card input (IBXS=0) is specified in the 18* array as follows:

1) If both B02=4 and B03=4, the complete input for the right boundary is entered first, followed by the complete input for the top boundary,
2) The angular fluxes are entered in order by angle, interval, and group,
3) For the top boundary the interval sweep is from left to right,
4) For the right boundary the interval sweep is from bottom to top,
5) For the top boundary a total of A06*IM*IGM entries are required. For each interval and group the A06 angular entries are ordered as they are specified by the quadrature directions set (7*); however, data are entered only for those angles for which $\eta < 0$. Initial directions (weight=0.0) are included,
6) For the right boundary a total of $\left[(A04-A07-A08)/2+A07+A08\right]$ *JM*IGM entries are required. For each interval and group, the angular entries are ordered as they are specified by the quadrature set; however, data are entered only for those angles for which $\mu < 0$. Initial directions are included, and
7) If the total number of source entries exceeds the number specified by ISIZE on Card 1 of Data Set 1, DOT-IIW will be unable to write the boundary source tape and execution will be terminated.

A boundary source from tape (IBXS=1) is obtained at present from either a previous DOT-IIW calculation or a MAP calculation. At present, only a top boundary source may be input from tape.

The top boundary source, whether from cards or tape, must always be contained in the first A06 angles. The first A06 entries in the 6* and 7* (quadrature data) arrays for that boundary source problem must represent the quadrature data in the $(-\eta)$ direction followed by the quadrature data in the $(+\eta)$ direction. Often, this means that the geometry for the second DOT-IIW calculation in a coupled geometry calculation must be inverted in the z direction with respect to the first DOT-IIW calculation so that the upward directed $(+\eta)$ angular fluxes from the first DOT-IIW calculation can be input as a downward directed $(-\eta)$ fixed boundary source for the second DOT-IIW calculation. However, if the user had inverted the geometry in the first DOT-IIW calculation in this example, then the downward directed ($-\eta$) angular fluxes from the first DOT-IIW calculation would be input as a downward directed ($-\eta$) angular fixed boundary source for the second DOT-IIW calculation. Thus the geometry for the second DOT-IIW calculation would not have to be inverted.

It is important to achieve a flux convergence on inner iterations by using a pointwise flux convergence criteria because the scattering sources for lower energy groups depend on flux solutions in the higher energy groups. The DOT-IIW code solves for the energy dependent flux from high energy group to low energy group, and any error in the flux solution in a higher energy group tends to propagate errors in the solution in lower energy groups. For this reason, the maximum number of inner iterations per group required to achieve pointwise flux convergence can vary from 10 to 100 depending on the system under analysis.

If no fissions are included, a flux guess of all 0.0s is sufficient. Additional information on convergence and normalization are given in Section 2.3.8 on "Other Useful Information".

2.3.4 Search Calculations

The DOT-IIW code will perform searches for the following quantities:

1) Time absorption (Rossi α),
2) Material concentration, or
3) Zone thickness

In each case the searches proceed in the following manner:

1) Using EV, the initial eigenvalue, outer iterations are performed until the absolute difference between two successive LAMBDAs is less than 3.0* EPSA. When this test is satisfied, a new eigenvalue is determined by EV ± EVM, where the plus is taken if the system is supercritical.
2) Using EV ± EVM, iterations are performed until successive LAMBDAs differ by less than EPSA. When this is met, a linear extrapolation is performed to determine an EV such that LAMBDA = 1.0.
3) Using the new EV, iterations are performed until successive LAMBDAs differ by less than EPSA. When this requirement is met, a quadratic extrapolation is

performed to determine an EV for LAMBDA = 1.0. This step is repeated until $|1.0 - \text{LAMBDA}| < \text{LAL}$. When this requirement is met, a linear extrapolation is performed in each iteration until two successive LAMBDAs are within EPS of 1.0.

In a Rossi α search, the eigenvalue determined is α in the quantity α/v, the amount of 1/v absorption needed to satisfy LAMBDA = 1.0. In a concentration search, the eigenvalue is determined by its use in the mixing table. This application is very general.

Clever use of the mixing table will allow searches on several elements while maintaining volume fractions, isotope ratios, etc. The final concentration from the search may be determined by inserting the eigenvalue into the specified mixing table positions and computing the new cross sections, and hence, the new concentration.

In a zone thickness search, the input radial and axial interval sizes are multiplied by the corresponding radial and axial modifiers times the eigenvalue. The correspondence is given by the radial and axial search zone numbers which are specified by interval. For example, in a problem with 10 radial intervals and 10 axial intervals, the search specifications,

```
21$   1   1   1   1   1   2   2   2   2   2

22*   0.0   1.0

23$   1   1   1   1   1   2   2   2   2   2

24*   0.0   0.5
```

will cause the first five radial and axial intervals to remain fixed, while the last five radial intervals are varied twice as fast as the last five axial intervals. The final values of the radial and axial intervals are printed out.

If S02=0, all the above searches will search for a system having a k of unity. If a parametric search is specified, one may determine an α, concentration, or zone thickness for a specified k, or the concentration or zone thickness for a specified α. If S02=0, the LAMBDA printed in the monitor line is equivalent to an unconverged k. If a parametric search is specified, k is equal to LAMBDA times the parametric k or LAMBDA times the k corresponding to the parametric α.

2.3.5 Limitations

In the application of discrete ordinate transport techniques, in nuclear or radiation shield design problems, two types of limitations can be encountered: the first limitation occurs when the application of the two-dimensional discrete ordinate transport method to a calculation is inadequate or inapplicable, and the second limitation occurs due to insufficient core data storage space.

The first limitation must be realized by the user. F. R. Mynatt, in a paper entitled, "The Discrete Ordinates Method Problems Involving Deep Penetrations", [9] outlines some of the basic assumptions and approximations involved in the method and portions are abstracted here:

> " . . . .The linear Boltzmann equation for transport theory is not derived from first principles of physics. On the contrary, it is stated as a flow balance for a differential phase space cell, treating in a phenomenological manner the events causing an increase or decrease in the number of particles contained in the cell. The discrete ordinates difference equation may be stated in an equivalent manner for a finite or differential phase space cell, and this is the manner in which the equation is presented in most references. In fact, for some time it was questioned as to whether the discrete ordinates equations would in general approach the analytic form of the Boltzmann equation as the finite difference phase space cell approached differential size. . .
>
> ' . . . .In order to discuss the application of the discrete ordinates method to deep penetration problems, the basic approximations will be reviewed. The definition of a finite phase space mesh and the subsequent approximations involved in integrating the differential equation over a mesh cell constitute the major approximation. The space, angle, and energy mesh should be sufficiently fine to give the desired resolution in the angular dependent spectra, and to provide sufficient accuracy for the mean value approximation as used in the convection terms of the transport equation. Although it is relatively easy to choose a mesh for a desired resolution it is not currently possible to determine the accuracy of the difference equations for a specific mesh for nonanalytic problems. Since the mesh is adjustable, current practice is to first select a reasonable mesh based on experience and then make a few adjustments to determine the effect of a finer mesh on the desired answer. For deep penetration problems, it is particularly true that one cannot use a crude mesh in energy, space, or angle. For example, extreme penetration in one-dimensional geometry have occasionally required 400 space intervals, 100 energy groups, and 32 angle intervals.

The typical one-dimensional shielding problem uses 100 - 200 space points, 30 to 100 energy groups, and 16 to 64 angles.

'. . . .The accuracy of the multigroup constants is, of course, closely related to the energy mesh. In the derivation presented, the multigroup procedure is exact and would, in fact, be so if the weighting functions were exactly known. In practice, the best that is done is to assume weighting functions to get fine group cross sections and then perform a transport calculation with fine groups to compute the weighting functions to reduce to perhaps 20 or 30 broader groups.

'. . . .The remaining major approximation in the method is the truncated polynomial expansion of the differential scattering cross sections. There are really two types of anisotropic scattering: first, the heavy nuclide elastic scattering of neutrons which at high energies is extremely anisotropic, but the angle energy correlation is unimportant; second is the elastic scattering of neutrons by hydrogen or the Compton scattering of gammas which has an important angle energy correlation which becomes an angle group correlation. The method used for anisotropic scattering in the discrete ordinates equations appears to work very well for both types of scattering. Experience to date has shown that low order approximations such as P_2 and P_3 are adequate for most practical problems, and rather severe problems have been adequately resolved with P_5 or P_6.

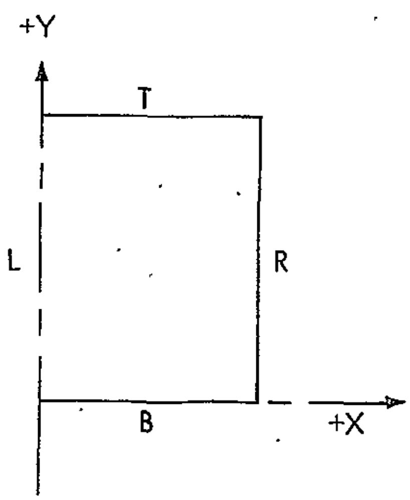
'. . . .There is an important difference between the anisotropic scattering technique used in the discrete ordinates method and the techniques based on Legendre polynomials which are frequently used with Monte Carlo or moments methods. In the discrete ordinates method the energy and angle effects of scattering are described independently. That is to say that the scattering law is not included in the discrete ordinates method but is implied in the cross section matrices. As a result of this, the energy transfer cross sections may be conveniently based on much more accurate information than the angular information. For example, the multigroup transfer coefficients may be derived from data including a P_{15} expansion of the differential scattering cross section in the center of mass system, while the final results will be used for a P_3 expansion in the laboratory system. Thus, a P_3 ANISN calculation may be superior to a Monte Carlo calculation, using a P_3 representation of the same basic data. The evidence to date indicates that a good description of the energy transfer effect requires a higher order approximation than is necessary to adequately describe the angle effect . . . .

". . . . In summary, the discrete ordinates method appears very attractive for use in shielding problems. The development of a general technique for anisotropic scattering, the use of step function differencing as an alternative to diamond differencing in the event of a negative flux, and new convergence criteria have, when applied in codes developed for the large new computers, given good solutions to difficult problems. Current work in convergence acceleration and other techniques such as analytic first collision sources in two-dimensional geometry has shown promise of further improving the technique."

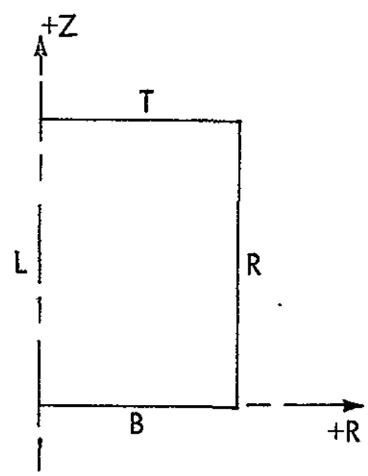
The second limitation of insufficient core data storage space results from attempting to run too large a problem for the amount of data storage specified in the input data. At MSFC, 65K of core storage is available on the UNIVAC 1108 for use with DOT-IIW. Because the DOT program is written in variable dimension, on any given data array no size restriction is imposed; a size restriction is only imposed on the length of the sum of all data arrays. For this reason, changing the code to use more core storage for data, should it become available at MSFC, can be easily accomplished by changing only one FORTRAN card in the main program of the DOT-IIW code. At present, approximately $51,000_{10}$ locations (ISIZE) are available for data storage.

2.3.6 Boundary Conditions

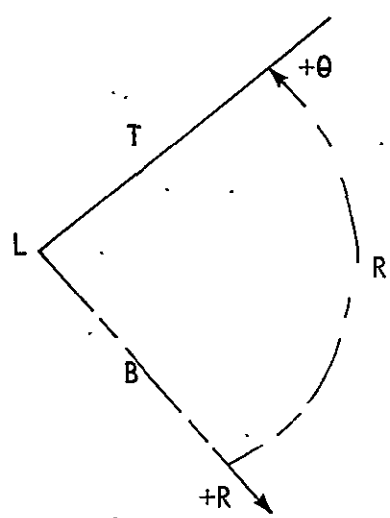
The DOT-IIW code has provisions for specifying the boundary conditions at each of the four external surfaces of a problem. These four boundaries are labeled "left", "right", "top", and "bottom" as indicated below for the various geometries.



x, y Geometry



r, z Geometry



r, θ Geometry

The user has a choice of the following six boundary conditions:

1) Vacuum - the angular flux, $\phi(r, z, E, \vec{\Omega})$, leaving the specified boundary is not returned. The code allows the particles to escape from the system.

2) Reflective - the angular flux, ϕ, $(r, z, E, \vec{\Omega})$, leaving the specified boundary is returned at the same boundary with perfect, mirror reflection as a function of spatial position, energy, and angle; i.e., the exiting flux is returned in the exact opposite direction in which it left the system.

3) Periodic - the angular flux, $\phi(r, z, E, \vec{\Omega})$, leaving the specified boundary is returned at the opposite boundary as a function of spatial position, energy, and angle, i.e., the exiting flux at the right boundary (or top boundary) is returned in the exact direction in which it left the system at the left boundary (or bottom boundary).

4) White - the angular flux, $\phi(r, z, E, \vec{\Omega})$, leaving the specified boundary is integrated over the angular variable, $\vec{\Omega}$. This flux is then returned isotropically at the same boundary as a function of spatial position, energy, and angle.

5) Albedo - the angular flux, $\phi(r, z, E, \vec{\Omega})$, leaving the specified boundary is integrated over the angular variable, $\vec{\Omega}$. The flux is then returned isotropically at the same boundary as a function of spatial position, energy, and angle, proportioned by the space-and energy-dependent input albedo (or fraction of returning particles).

6) Source - the angular flux $\phi(r, z, E, \vec{\Omega})$, leaving the specified boundary is not returned. The angular flux that is returned at the same boundary is the input angular flux, (boundary source) as a function of spatial position, energy, and angle.

The code allows the following choices of boundary conditions:

Left	Right	Top	Bottom
Vacuum	Vacuum	Vacuum	Vacuum
Reflective	Reflective	Reflective	Reflective
Periodic	Periodic	Periodic	Periodic
	White	White	White
	Albedo	Albedo	Albedo
	Source	Source	

By careful forethought, the use of symmetry conditions in setting up the problem geometry may reduce problem complexity by a factor of two or more. It is also evident that:

1) A vacuum boundary condition at the left boundary is impossible for r, z and r, θ geometries.
2) A periodic boundary condition for one boundary is an impossible specification. Opposite boundaries or all four boundaries must be specified as periodic.
3) A periodic boundary condition at the left and right boundary is impossible for r, z and r, θ geometries.
4) A reflective right boundary condition is impossible for r, z and r, θ geometries.
5) An input albedo boundary specification greater than 1.0 generates particles.

2.3.7 Other Useful Information

Balance Table Description

The DOT-IIW program reads as input data, or calculates the following quantities:

Name	Description
(1) $FXS_{i,j,g}$	, the fixed distributed or fixed boundary source as a function of mesh interval i, j and group, g
(2) K7g	, the fractional fission spectrum as a function of energy group, g
(3) $V0_{i,j}$	, the volume element at each radial and axial mesh interval, i, j $(x_{i+1}-x_i)(y_{i+1}-y_i)$, $\pi(r^2_{i+1}-r^2_i)(z_{i+1}-z_i)$, $(r^2_{i+1}-r^2_i)(\theta_{i+1}-\theta_i)(0.5)$, for (x, y), (r, z), or (r, θ) geometries, respectively.

(4) $N2_{i,j,g}$, scalar flux as a function of mesh interval i, j and energy group, g.

(5) w_m , angular quadrature weights as a function of space angle, m.

(6) η_m , angular quadrature direction cosines as a function of space angle, m.

(7) μ_m , angular quadrature direction cosines as a function of space angle, m.

(8) $FD_{i,j}$, the fission density as a function of mesh interval i, j.

(9) $\nu \Sigma_{f,g,k}$ Nu times fission (the neutron production) cross section as a function of energy group, g, and interval, k.

(10) A0(1) , 1.0, $2\pi r_1$, $2\pi r_1$, for (x,y), (r,z), or (r,θ) geometries, respectively.

(11) A0(IP) , 1.0, $2\pi r_{IM+1}$, $2\pi r_{IM+1}$, for (x,y), (r,z), or (r,θ) geometries, respectively.

(12) $Z5_j$, $(y_{j+1}-y_j)$, $(z_{j+1}-z_j)$, or $(\theta_{j+1}-\theta_j)$ for (x,y), (r,z), or (r,θ) geometries, respectively.

(13) A^1_i , $(x_{i+1}-x_i)$, $\pi(r^2_{i+1}-r^2_i)$, or $(r_{i+1}-r_i)$ for (x,y), (r,z), or (r,θ) geometries, respectively.

(14) B0, B2, B4, B6 , are surface angular fluxes as a function of space point, angle, and energy group.

(15) i , radial mesh interval

(16) j , axial mesh interval

(17) g , energy group

(18) k , material

(19) m , space angle

Each column printed in the balance tables can now be defined.

Fixed Source

$$E0_g = \sum_i \sum_j FXS_{i,j,g} \times VO_{i,j}$$

Fission Source

$$E1_g = \frac{1}{k_{eff}} \times \sum_k \sum_i \sum_j VO_{i,j} \times \nu\Sigma_{f\,g,k} \times K7_g \times N2_{i,j,g}$$

In Scatter

$$E2_g = \sum_k \sum_i \sum_j \left[\Sigma^{g,k}_{g' \rightarrow g} \times N2_{i,j,g'} \times VO_{i,j} \right] \text{ for } g' \neq g$$

Self Scatter

$$E3_g = \sum_k \sum_i \sum_j \left[\Sigma^{g,k}_{g' \rightarrow g} \times N2_{i,j,g'} \times VO_{i,j} \right] \text{ for } g' = g$$

Horizontal Leakage

We define:

$$VRL_g = \sum_j \sum_m (A0\,(IP) \times Z5_j \times W0_m \times \mu_m \times (B0_{j,m,g} + B2_{j,m,g}))\text{ for } \mu > 0$$

$$VLL_g = \sum_j \sum_m (A0\,(1) \times Z5_j \times WO \times \mu_m \times (B0_{j,m,g} + B2_{j,m,g}))\text{ for } \mu < 0$$

then:

$$E4_g = VRL_g - VLL_g$$

Absorptions

$$E5_g = \sum_k \sum_i \sum_j \left[\Sigma_a^{g,k} \times N2_{i,j,g} \times VO_{i,j} \right]$$

Out Scatter

$$E6_g = \sum_k \sum_i \sum_j \left[\Sigma_t^{g,k} \times N2_{i,j,g} \times VO_{i,j} \right] - E5_g - E3_g$$

Right Leakage

$$E7_g = VRL_g$$

Vertical Leakage

We define:

$$VTL_g = \sum_i \sum_m (A1_i \times WO_m \times \eta_m \times (B4_{i,m,g} + B6_{i,m,g})) \text{ for } \eta > 0$$

$$VBL_g = \sum_i \sum_m (A1_i \times WO_m \times \eta_m \times (B4_{i,m,g} + B6_{i,m,g})) \text{ for } \eta < 0$$

then:

$$F5_g = VTL_g - VBL_g$$

Top Leakage

$$F6_g = VTL_g$$

Net Leakage

$$F7_g = (VRL_g - VLL_g) + (VTL_g - VBL_g)$$

Balance

$$A7_g = \left| \frac{E0_g + E1_g + E2_g - F7_g - E5_g - E6_g}{E0_g + E1_g + E2_g} \right|$$

NOTE: 1) If $E0_g + E1_g + E2_g = 0$, then the denominator above is replaced by 1.0.

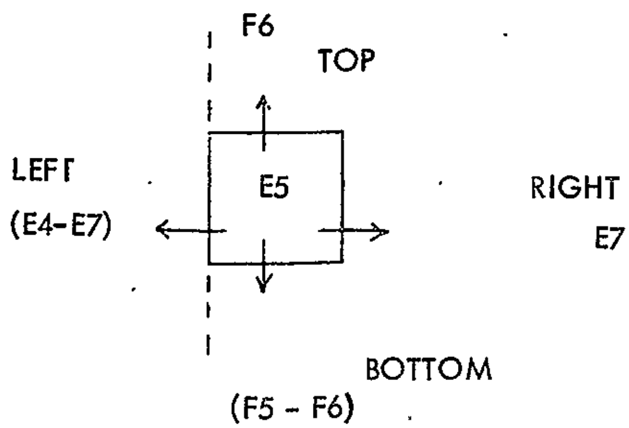
2) If I04 = 5, $E0_g$ is not included in the above equation.

The DOT-IIW code prints the above 12 quantities by group as well as the sum over all groups summed over the whole geometry.

Certain relationships and conditions that should exist among the various entries in the balance tables are:

1) The sum of the net leakage plus the absorption should equal the fixed source plus the fission source (except for boundary source calculations).
2) The in-scatter into group 1 should be zero (numerically, it will be six decades or more below the other entries in the in-scatter column).
3) The out-scatter from group IGM should be zero in problems without upscatter (numerically, it will be six decades or more below the other entries in the out-scatter column
4) In k-calculations, if the entries in the fission source column do not equal the 1* array times S01, then the entries in the 1* array do not add up to 1.0.
5) The total in-scatter should equal the total out-scatter.

For k-calculations (I04 = 1, 2, 3, or 4):

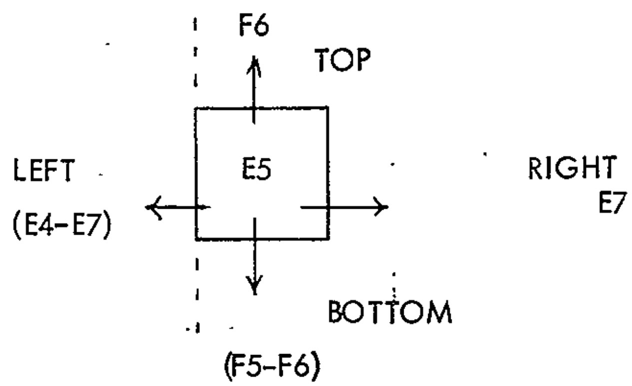


For the system,

E0 + E1 + E2

= E5 + E6 + E4 + F5

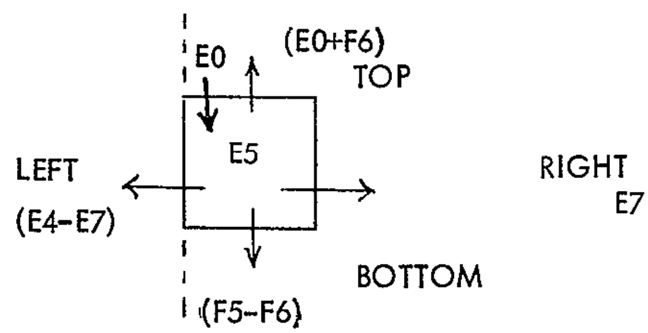
For distributed source calculations (I04 = 0):



For the system,

E0+E1+E2=E5+E6+E4+F5

For boundary source calculations (I04=5):



For the system,

E2=E5+E6+F7

Description of Cross-Section Input

The cross sections from cards are entered by table position, group, and material. The cross section table for group g of material M is arranged as follows;

Table Position Number	Type of Cross Section	
1	Σ_a^g	
2	$\nu\Sigma_f^g$	
3 (IHT)	Σ_T^g	
4	$\Sigma_{g+M\to g}$	Upscatter Cross Sections
5	$\Sigma_{g+M-1\to g}$	
.		
. (IHS)	$\Sigma_{g\to g}$	
.	$\Sigma_{g-1\to g}$	Downscatter Cross Sections
.		
.		
. (ITL)	$\Sigma_{g-N\to g}$	

where:

Σ_a^g = absorption cross section for group g

$\nu\Sigma_f^g$ = neutron production (Nu_x fission) cross section for group g

Σ_T^g = total collision cross section for group g

$\Sigma_{g+M\to g}$ = upscatter cross section from group g + M to g

$\Sigma_{g\to g}$ = within group scattering cross section for group g

$\Sigma_{g-N\to g}$ = downscatter cross section from group g-N to g

IHT = position of Σ_T^g

IHS = position of Σ_{gg}

ITL = length of table

M = maximum number of groups for upscatter

N = maximum number of groups for downscatter

The cross section data are entered for each of the above ITL table positions for group 1 followed by the cross section data by table position for group 2, and for each group to group IGM for material 1. This format is then repeated for all materials. A complete cross section table must be entered for each group, table position, and material; e.g., zeros must be entered for impossible transfers such as downscatter positions in group 1. The cross section tables for the P_1, P_2, etc., scattering are ordered in the same form as the P_0 transfer matrix. For these tables $\sum_a^g = 0.0$, $\nu\sum_f^g = 0.0$, and $\sum_T^g = 0.0$.

Thus, the parameters IHT, IHS, and ITL completely describe the format of the cross sections. If there are no activity cross sections, IHT = 3. If there is no upscatter, IHS = IHT + 1. If there is no downscatter ITL = IHS (i.e., a one-group problem). If there is upscatter, DOT-IIW will compute a total upscatter cross section for each group of each material and place that cross section in position IHT + 1. This total upscatter cross section is printed output. The activity cross sections are used only for activities (19$, 20$) and need not appear in the calculation. The P_ℓ cross sections must contain a $(2\ell + 1)$ term. Previous S_n codes supplied this term internally. This factor may be included externally via the mixing table. APPROPOS and GAMLEG-W supply the $(2\ell+1)$ term required by DOT-IIW.

Description of Mixing Table

The DOT-IIW mixing table has the following form:

Mixture Sum (10$)	Component (11$)	Density (12*)
6	0	0.0
6	1	0.4
6	3	0.5
7	0	0.0
7	2	0.4
7	4	0.5
7	0	3.0
5	5	0.0

The input rules are as follows:

1) If the mixture number is some number, N, and the component number is 0, then the cross sections in mixture N will be multiplied by the number entered in the density column.

$(\Sigma_{\text{MIXTURE N}}\ (\text{NEW}) = \Sigma_{\text{MIXTURE N}}\ (\text{OLD}) * \text{DENSITY})$

2) If the mixture number is N and the component number is M, then the cross sections in component M will be multiplied by the density and added to the cross sections in mixture N.

$(\Sigma_{\text{MIXTURE N}}\ (\text{NEW}) = \Sigma_{\text{MIXTURE N}}\ (\text{OLD}) + \Sigma_{\text{COMP M}} * \text{DENSITY})$

3) If the mixture number is N, the component number is also N, and the density is zero, the cross sections in mixture N will be multiplied by the eigenvalue, EV. This should be used only in concentration searches.

4) Note that either a mixture or a component may be made up of microscopic or macroscopic cross sections for a single isotope or mixture of isotopes. For example, the mixture table given above would do the following:

(1) Clear the space for mixture 6. $\Sigma_6 = \Sigma_6 \times 0.0$

(2) Add components 1 and 3 with densities 0.4 and 0.5, respectively to form mixture 6.
$\Sigma_6 = \Sigma_1 \times 0.4 + \Sigma_3 \times 0.5$

(3) Clear mixture 7. $\Sigma_7 = \Sigma_7 \times 0.0$

(4) Add components 2 and 4 to form 7.
$\Sigma_7 = \Sigma_2 \times 0.4 + \Sigma_4 \times 0.5$

(5) Multiply mixture 7 by 3.0.
$\Sigma_7 = \Sigma_7 \times 3.0$

(6) Multiply mixture 5 by the eigenvalue.
$\Sigma_5 = \Sigma_5 \times EV$

Material Numbers

All cross section sets, whether elements or mixtures, are referred to by a continuous set of material numbers. In particular, the materials supplied in card form (14*, 14U, or 14V) become materials 1 through MCR, the materials read from the library tape become MCR + 1 through MCR + MTP, and any number greater than MCR + MTP, but less than or equal to MT refers to a mixture. A mode error will result if a material is referred to that is greater than MT.

When the order of scatter for any zone (a negative entry in the 9$ array) is greater than zero, DOT-IIW expects the P_1 cross sections to be material M + 1, the P_2 cross sections to be M + 2, etc., where M is the P_0 material number specified in the 9$ array.

If that material is anisotropic, it must have the order of P_ℓ scattering specified by A03. In other words, P_0 and P_1 or P_0 and P_3, respectively; but P_0 and P_1 or P_0, P_1, and P_3 materials may not be entered for problems declared P_3.

Activities

Activities may be computed by interval as specified by M05 on card 8. This option provides a rapid and economical way to obtain data such as reaction rates, dose rates, capture or other desired response rates. The interval activity is per unit volume. The following table illustrates the use of activity specifications.

	19$	20$
1.	1	3
2.	5	1

1. Compute activity for material 1, cross section position 3 in the intervals in which material 1 appears.
2. Compute activity for material 5, cross section position 1 in all intervals.

Albedo and Reflective Boundary Conditions

The albedo option allows the user to specify a space- and energy-dependent albedo at the top, right, and bottom boundaries of a problem. Inwardly directed (with respect to the problem) angular fluxes are returned isotropically, proportioned by the particular boundary interval albedo for that energy group. The user should check that the albedo and reflective boundary condition has been sufficiently satisfied as the problem convergence proceeds. This check is necessary because the returning angular fluxes at the top and right boundaries are computed from the previous inner iteration angular fluxes for that group.

Inner Iteration Convergence Options

The DOT-IIW code described in this report incorporates a choice of four techniques by which the scalar flux solution may be converged on inner iterations. The choices are:

1) A09 = 0, Gaussian Iteration (or Normal Iteration),
2) A09 = 1, Successive Overrelaxation,
3) A09 = 2, Space Point Scaling, and
4) A09 = 3, Chebyshev Acceleration.

Gaussian Iteration — Gaussian Iteration is the simplest method for solving iterative problems. This technique also requires the greatest number of iterations to meet a given convergence criteria. The amount of core data storage required for this technique is less than that required by any of the other techniques.

Successive Overrelaxation — Successive overrelaxation is an accelerating technique which is applied after every fourth Gaussian Iteration. Acceleration factors by mesh cell are applied to the scalar flux, angular flux, surface angular flux, and higher moments. These acceleration factors are dynamically computed from the N-1st, N-2nd, and N-3rd scalar fluxes. The technique requires IM*JM additional data locations. For a wide class of problems, this technique almost always converges in less inner iterations than the Gaussian Iteration technique. One exception is in deep penetration problems where the flux decreases many orders of magnitude.

Space Point Scaling — Space Point Scaling is an acceleration technique[10] which is applied after a predetermined number of Gaussian Iterations have been completed. The technique by which the scale cycle is determined is based on the maximum dominance ratio for that energy group. The dominance ratio is approximated by:

$$\lambda \approx \Sigma_{gg} / \Sigma_t$$

and is always less than 1.0.

The following histogram is used by the DOT-IIW code to determine when to apply Space Point Scaling:

Dominance Ratio	Scale Cycle
0.0 - 0.6	2
0.6 - 0.8	3
0.8 - 0.9	5
0.9 - 0.95	7
0.95 - 0.975	9
0.975 - 0.99	11
0.99 - 1.0	15

The code computes a space dependent acceleration factor by mesh interval after the appropriate number of Gaussian Iterations have been performed, and applies these acceleration factors to the scalar flux, angular flux, surface flux, and higher moments. The technique requires the greatest additional data locations of all the acceleration techniques (5*IM*JM).

The technique almost always converges in less inner iterations than the Gaussian Iteration Technique and is much faster for low dominance ratio problems (e.g., photon transport). The technique is particularly useful in deep penetration problems.

The user is cautioned that an undesirable interaction between negative flux fix-up (i.e., diamond difference breakdown) and Space Point Scaling exists. This effect can cause oscillatory results in the computed maximum flux deviation resulting in no convergence for the group in question. This interaction may be alleviated by setting MODE=3 and using the weighted difference equation solution.

Chebyshev Acceleration — Chebyshev Acceleration is an acceleration technique which is applied every iteration after the third Gaussian Iteration. A single acceleration factor is applied to the scalar flux, angular flux, surface flux, and higher moments based on the Chebyshev polynomial method of iteration. The technique requires IM*JM additional data locations. The technique should only be used in problems containing low dominance ratios and vacuum boundaries only; the technique fails for high dominance ratios.

Summary — The user must choose the acceleration technique to fit his problem. In general, the Chebyshev Acceleration Technique should not be used. In problems where data storage is not a limiting factor, Space Point Scaling should be used. For deep penetration problems or fixed distributed source problems, Space Point Scaling should be used. Where data storage is limited, Successive Overrelaxation should be used. Gaussian Iteration can be used in extreme data storage limited problems. Finally, the zones of convergence options can be used quite effectively to assist the problem in converging only in the zones of importance.

Convergence

The numerical solution of the multigroup discrete ordinate difference equations is carried as a two-level iterative scheme. The two types of iterations performed are the inner and the outer iteration. The inner iterations are the group iterations used to solve for the angular flux in all mesh cells for a particular group. An outer iteration is the iteration used to solve the complete set of group equations. From the comparison of sets of successive outer iterations, the eigenvalue and convergence can be evaluated.

Inner Iteration

The actual calculation in the DOT-IIW code proceeds from an input guess of group fluxes. The fission source, fixed source, and the in-scattering into the group (both isotropic and anisotropic) are assumed fixed within a group solution. The procedure used in DOT-IIW to solve the group fluxes is based on a set pattern in the solution of angular and scalar flux. The group calculation (an inner iteration) begins at the top-outermost boundary mesh cell (IM, JM). The top row (j = JM) angular fluxes are obtained by applying the top and right boundary conditions and solving the inward and downward discrete directions ($\mu_m < 0.0$ and $\eta_n < 0.0$) in an inward pass through the jth row mesh cell. The left boundary condition is applied using the inward angular flux data for the innermost mesh cell (i = 1). Then all outward and downward discrete directions are calculated in an outward pass through the jth mesh cell. The calculation then proceeds to the next row (j = JM -1), and angular fluxes are calculated in a similar manner using the angular flux data for the row above (j = JM). This procedure is followed to the j = 1 row at which time the bottom boundary condition is applied to calculate the upward angular flux at j = 1. The upward angular flux at row j = 1 is then used to calculate the upward discrete direction fluxes in a manner similar to the downward angular flux solution. The calculation proceeds from row j = 1 to row j = JM always using the flux data from the j - 1 row. The latest angular flux data at the left, right, top, and bottom boundaries are always used in the application of boundary conditions. This procedure completes an inner iteration.

The group inner iteration convergence is tested by comparing the error in one or more of the following quantities on successive inner iterations, 1) volume averaged fluxes, 2) pointwise, mesh cell fluxes, and/or 3) boundary fluxes in a group. Inner iterations are necessary to solve for within group scattering because neutrons may scatter from any angle to any other angle within the group, and the flux in all angles for all mesh cells is unknown at the beginning of the inner iteration loop. The inner iterations are continued until the scalar flux converges according to one of two criteria:

1. If pointwise scalar flux convergence is not desired, then an integral iteration test is used with EPS as the criteria. Convergence for group, g, is achieved if:

$$\left[\sum_i \sum_j \left| \frac{\varphi^{n}_{i,j,g} - \varphi^{n-1}_{i,j,g}}{\varphi^{n}_{i,j,g}} \times VO_{i,j} \right| \Big/ \sum_i \sum_j VO_{i,j} \right] \leq EPS$$

Where VO is the volume element by mesh cell and is summed over the entire system volume or the volume of the zones of convergence specified by A10 and the 28$ array.

2. If pointwise scalar flux convergence is desired (G06≠0), then a pointwise scalar flux criterion is used over the entire system, or over the zones of convergence specified by A10 and the 28$ array with G06 as the criteria.

   Convergence is achieved if:

$$\text{MAX} \left| \frac{\varphi^{n}_{i,j,g} - \varphi^{n-1}_{i,j,g}}{\varphi^{n}_{i,j,g}} \right| \leq G06$$

for each i, j mesh cell of interest.

Where the maximum flux deviation is sought over every mesh cell, i, j, in the system, or in the mesh cells of the zones of convergence specified by A10 and the 28$ array. Inner iterations are also terminated if the maximum number of inner iterations per group is reached.

Outer Iteration

When carrying an out outer iteration, the calculation proceeds downward in energy; i.e., convergence is attained by inner iteration in the highest energy group before starting on the next lower energy group. When calculating the "downscattering" portion of the source into any group, the new fluxes which have been calculated for the higher energy groups are used; however, the old fluxes must be used for the "upscatter" portion of the source. Hence, the fission source and the upscatter source are computed after all groups are solved. The iterations which are carried out to give upscatter and fission source convergence are called outer iterations. The calculation over all groups of the flux solution, therefore, comprises one outer iteration.

The fission neutron production rate by mesh cell is computed after a complete outer iteration as:

$$FO_{i,j} = \sum_g \sum_m \left\{ \nu\Sigma_f^{m,g} \times \varphi_{i,j,g} \times VO_{i,j} \right\}$$

where:

$\nu\Sigma_f$ is the neutron production cross section,

φ is the scalar flux, and

VO is the mesh cell volume

At the same time, the upscatter source is computed as:

$$UPI = \sum_g \sum_m \sum_j \sum_i \left\{ \Sigma_{g' \to g}^{g,m} \times \varphi_{i,j,g'} \times VO_{i,j} \right\}$$

where: $\Sigma_{g' \to g}^{g,m}$ is the total upscatter cross section

The fission source rate is then computed as:

$$S_n = \sum_g \sum_m \sum_j \sum_i \left\{ \nu\Sigma_f^{m,g} \times \varphi_{i,j,g} \times K7_g \times VO_{i,j,g} \right\}$$

where: K7 is the fission spectrum.

Next, λ, or the multiplication ratio is obtained by taking the ratio of the new fission source rate to the old (previous iteration) fission source rate.

For fixed distributed or boundary source calculation with fissions, the fixed source is added to the fission source rate in the computation of λ.

Outer iteration is continued until:

$$\left| 1 - \lambda^n \right| < \text{EPS}$$

and

$$\left| 1 - \frac{UPI^n}{UPI^{n-1}} \right| < A14$$

are satisfied.

If convergence is not achieved, the fission spectrum and fission neutron production rate are scaled by $1/\lambda$ so that λ approaches unity as the iteration proceeds. The input values of the fission spectrum (1*) are saved by the DOT-IIW code, and the fission spectrum that is scaled is a temporary quantity. To compute the eigenvalue, the code solves the following equation

$$k_{eff} = \sum_g K7g^* / \sum_g K7g$$

where K7g* are the input values of the fission spectrum. The eigenvalue is also the product of successive λs.

The next calculation is dependent on the type of problem being solved. If the problem is an eigenvalue or parametric eigenvalue calculation, the program proceeds to the next outer iteration using a calculated (scaled) estimate of power (or eigenvalue) as the fission density and scalar flux guess. This procedure is followed for both eigenvalue or parametric eigenvalue calculations, but in parametric eigenvalue calculations the concentrations, dimensions, or fluxes are modified after program-selected outer iterations.

In fixed distributed source calculations without fissions (e.g., photon transport) the angular and scalar fluxes are obtained with a single outer iteration since particles are not transported from a lower group to a higher group by fission or upscatter. Hence, a single outer iteration yields a solution of the photon energy angular and scalar fluxes.

2.4 PROBLEM SETUP INFORMATION

This section describes the data deck setup for the DOT-IIW code. Information on tape assignments, running time, recommended debug procedure, and error messages is provided.

2.4.1 Tape Assignments

The DOT-IIW code has been placed on the MSFC, UNIVAC-1108 computer under the EXEC8 Monitor System. Under this System, the DOT-IIW code may require a maximum of eight tapes or disks. In some instances, disk devices (FASTRAND) can be substituted for scratch tapes, depending on the complexity of the calculation. The tape assignments are as follows:

Tape 1, Tape 2, Tape 3	Scratch Tapes or Disks, always required.
Tape 4	Tape or Disk, required if IAFT > 0
Tape 5	Input Disk
Tape 6	Output Disk
Tape 8	Fixed Distributed Source Input Tape, M06 = 5
Tape 9	Fixed Boundary Source Input Tape, IBXS = 1
Tape 11	Scalar and Surface Angular Flux Output Tape
Tape 12	Flux Guess Input Tape, M07 = 5
Tape 14	Cross Section Library Tape, MTP > 0

Tape 8 and 9 can never be requested simultaneously.

To reduce Peripheral Processor Unit (PPU) time and elapsed time, the following quantity should be evaluated :

$$NWORDS = \left\{(IM*JM) + (A04*JM) + (A04*IM) + \left([(A03*(A03+3))/2] *IM*JM\right)\right\}$$

If NWORDS is less than 4000, tape devices should be specified for tapes 1, 2, and 3. If NWORDS is greater than 4000, disk devices should be used for tapes 1, 2, and 3. Simply stated, tapes are much faster than disks for short records. If scratch tapes are not specifically requested, disk devices (FASTRAND) are automatically assigned.

2.4.2 Running Time

The required running time for a given DOT-IIW calculation on the UNIVAC-1108 computer is fairly easy to calculate if the total number of inner iterations required for the calculation can be determined. The following equation is evaluated:

$$\text{CP time (seconds)} = \frac{IM*JM*A04*TI}{S}$$

where:

IM is the number of radial mesh intervals in the calculation

JM is the number of axial mesh intervals in the calculation

A04 is the number of space angles in the calculation

TI is the total number of inner iterations required for the entire calculation

S is the number of angular flux calculations per second as a function of P_ℓ scattering as follows:

S_{P_0} = 5430 calculations/second

S_{P_1} = 3940 calculations/second

S_{P_3} = 3220 calculations/second

Although a finite setup time is required, (approximately 20 to 70 CPU seconds) and is not included in the above equation, the use of the above equation yields reasonably accurate time estimates.

2.4.3 Recommended Problem Debug Procedure

By temporarily setting D05 and IAFT = 0, a complete input printout can be obtained in less than 60 CPU seconds in all but the largest calculations, where perhaps 90 CPU seconds may be required. This procedure is highly recommended where a complete set of input data has been assembled from scratch. If only minor changes are made to an existing working DOT-IIW data deck, then the above procedure is optional. All input data will be printed out and the code will perform the standard input data error checks.

2.4.4 Error Messages

The following DOT-IIW code generated error message may be encountered:

Message Code	Description or Explanation
SN 64	A05 + A06 $\neq$ A04; Quadrature parameters incorrect.
I04 66	No IZ or JZ arrays were input for a zone thickness search calculation.
S03 69	No parametric eigenvalue was input for parametric eigenvalue search calculation.
IBSS 00	Insufficient core storage to read in the fixed boundary source.
—— ——	"Program capacity exceeded". Problem is too large to fit on the computer or else the value of ISIZE was input incorrectly.
—— ——	"There is an error in the input data or the logical tape number assigned to NAFT exceeds 15." There is an input data error, usually.

— —	"Error, N entries required in (3*, for example) array, data edit continues." The improper number of entries were input or else a T card is missing.
— —	"Warning, Interpolation used in (9$, for example) integer array, data edit continues."
— —	"Fill option ignored in (9$, for example) array." An array does not require any storage or else on input data section is missing.
— —	"Warning, Address ________ is beyond limits of (9$, for example) array."
S804 404	M7 (I) = 0.0. One of the η values in the 6* array is zero.
S804 604	M5 (I) = 0.0. One of the μ values in the 6* array is zero.
S804 1404	Error in direction cosines. Asymmetry in the $+\mu$ and $-\mu$ direction.
S807 2004	$\left[\left\|\sum WO_i \times \eta_i\right\| + \left\|\sum WO_i - 1.0\right\| + \left\|\sum WO_i \times \mu_i\right\|\right] > 1.0\times10$
S807 7807	Error in Mixture Vector. The entry in the 10$ array is greater than the value specified for MT.
S807 1010	Error in θ coordinates in r, θ geometry
R5 1911	Error in radial dimensions, non-increasing values.
Z5 2111	Error in axial dimensions, non-increasing values.
NB 347	Error in neutron balance table.
S851 1068	Total fission in problem equal zero and 104 = 1, 2, 3, or 4
MNPR 106	Internal parameter NGO improperly set.

Message	Explanation
Error Mode: Type = 01, Code = 02, ERR, Address = ______________.	This error usually occurs when too large an angular flux tape is being generated. The solution to the problem is to reserve the angular fluxes on a disc and immediately process the disk for further calculations or set A11 to the desired mesh interval if all flux intervals are not needed.
The Interpolation of Meaningless Input was Attempted. I/0 called at Sequence. Number_____of Subroutine______.	Floating point data where fixed point data belongs or a title card where data belongs.
Error Mode: Type = 01, Code = 04, ERR, Address = ______________.	Flux guess tape may have insufficient number of mesh or groups.
MAX TIME	Insufficient CP time specified. If more than one outer iteration was performed, a flux guess may be salvaged.

Other system generated error messages may be encountered, and the user should consult a UNIVAC-1108 Fortran Reference Manual[11] for an explanation.

2.4.5 Sample Problem Input

Two DOT-IIW sample problems have been included in Table 2-5 to illustrate the following:

1) The flexibility of the input data formats, and
2) The structure of a complete problem.

The first sample problem is an S_4, P_3, 3 energy group, eigenvalue calculation in r, z geometry. A flux guess has been supplied from cards. The second sample problem is a fixed volume distributed source calculation utilizing identical cross sections as were used in the first sample problem. Only one outer iteration is required for the second sample problem.

TABLE 2-5

SAMPLE PROBLEM CARD INPUT (Sheet 1 of 5)

```
       30000    5    6    1    2    8    3    4    0    0    0    0    0    0    0          DATA  10
DCT SAMPLE PROBLEM NUMBER 1, 3 GROUP,S4,P3,R-Z,K-CALCULATION                              DATA  20
          13             0             3             16             1            3DATA  30
          35             3             1            0.0           0.0      0.0001DATA  40
           1             0             3              3             1            1DATA  50
          12            12            12              0             0            0DATA  60
           0           0.0             3              3             4            6DATA  70
         1.0             6             0             30            20           30DATA  80
         0.0        0.0002           0.0            0.0           0.0          0.0DATA  90
           0             8             8              2             2            0DATA 100
           0             0             3              0           0.0            0DATA 110
14*           .0013792     .0024645     .49223       .44107      2R 0.0       DATA 120
  .019753     .026816      1.2648       1.1946       .049779      0.0         DATA 130
  .17713      .30205       1.686        1.5089       .050405      1.3637 -6DATA 140
 3R 0.0       .65001      5R 0.0        1.8407       .034195     5R 0.0       DATA 150
  .050124     4.9522 -9   3R 0.0        .53976      5R 0.0        1.2118      DATA 160
  -.015334   5R 0.0       -.047187     -7.782 -7   3R 0.0         .17246      DATA 170
 5R 0.0       .098833     -.082968    5R 0.0       -.082467      -2.1059-8DATA 180
  4.5227 -4   0.0          3.2087 -1    3.2015E-1  2R0.0          6.6839 -3DATA 190
  0.0         .78553       .77793       2.679  -4   0.0           .077168     DATA 200
  0.0         .98114       .90397       .0009081    0.0          3R0.0        DATA 210
  .18971     5R0.0         .089185     -1.073 -4   5R0.0          -4.8303-4DATA 220
  0.0        3R 0.0        .3179       5R 0.0       .048595       -1.338 -6DATA 230
 5R 0.0       -1.4316-5    0.0         3R 0.0        .1362        5R 0.0       DATA 240
  .027748     1.7342 -6   5R 0.0        3.9839 -6   0.0           1.8274 -4DATA 250
  0.0         .6095        .52306      2R0.0         7.6982 -4    0.0         DATA 260
  1.4654      1.3709       .086251      0.0          8.6944 -3    0.0         DATA 270
  1.7937      1.785        .093634      2.3664 -6   3R 0.0        .89753      DATA 280
 5R 0.0       2.5966       .055036     5R 0.0        .095594      7.9635 -9DATA 290
 3R 0.0       .67262      5R 0.0        1.7216      -.02761      5R 0.0       DATA 300
  -.046302    -1.3477-6   3R 0.0        .3191       5R 0.0        .158        DATA 310
  -4.3936-2  5R 0.0       -.14892      -1.0918-8    T                         DATA 320
 3*                                                                           DATA 330
     2.73         2.71         2.69         2.66         2.61         2.55    DATA 340
     2.49         2.41         2.32         2.23         2.12         2.00    DATA 350
     1.98         1.75         1.61         1.47         1.32         1.16    DATA 360
     1.00         .822         .671         .568         .468         .324    DATA 370
     .185         .108         .0623        .0361        .0211        .0121   DATA 380
     .00706       .00405       .00230       .00122       .000548              DATA 390
     2.73         2.72         2.69         2.66         2.61         2.56    DATA 400
     2.49         2.41         2.33         2.23         2.12         2.01    DATA 410
     1.88         1.75         1.61         1.47         1.32         1.16    DATA 420
     1.00         .825         .673         .568         .464         .319    DATA 430
     .182         .106         .0612        .0356        .0206        .0120   DATA 440
     .00689       .00401       .00224       .00122       .000512              DATA 450
     2.73         2.71         2.69         2.66         2.61         2.55    DATA 460
     2.49         2.41         2.32         2.23         2.12         2.00    DATA 470
     1.88         1.75         1.61         1.47         1.32         1.16    DATA 480
     1.00         .822         .671         .568         .468         .324    DATA 490
     .185         .108         .0623        .0361        .0211        .0121   DATA 500
     .00706       .00405       .00230       .00122       .000548              DATA 510
 T                                                                            DATA 520
 3*                                                                           DATA 530
     1.84         1.84         1.82         1.79         1.77         1.73    DATA 540
     1.68         1.63         1.57         1.51         1.44         1.36    DATA 550
     1.28         1.19         1.09         .994         .892         .786    DATA 560
     .678         .567         .482         .425         .373         .302    DATA 570
     .216         .147         .0969        .0623        .0396        .0247   DATA 580
     .0152        .00927       .00546       .00307       .00136               DATA 590
     1.84         1.83         1.82         1.80         1.77         1.73    DATA 600
     1.69         1.63         1.58         1.51         1.44         1.36    DATA 610
     1.28         1.19         1.09         .994         .892         .786    DATA 620
```

TABLE 2-5

(Sheet 2 of 5)

```
.677        .568        .482        .425        .372        .301       DATA 630
.216        .146        .C965       .0621       .0393       .0245      DATA 640
.0152       .00921      .C0544      .00304      .00133                 DATA 650
1.84        1.84        1.82        1.79        1.77        1.73       DATA 660
1.68        1.63        1.57        1.51        1.44        1.36       DATA 670
1.28        1.19        1.09        .994        .892        .786       DATA 680
.678        .567        .482        .425        .373        .302       DATA 690
.216        .147        .0969       .0623       .0396       .0247      DATA 700
.0152       .00927      .C0546      .G0307      .00136                 DATA 710
T                                                                      DATA 720
3*                                                                     DATA 730
.520        .517        .513        .507        .498        .488       DATA 740
.475        .460        .444        .425        .405        .383       DATA 750
.359        .334        .308        .281        .254        .230       DATA 760
.216        .230        .262        .302        .368        .520       DATA 770
.653        .661        .609        .526        .435        .347       DATA 780
.267        .197        .136        .0836       .0349                  DATA 790
.520        .518        .513        .507        .498        .488       DATA 800
.475        .461        .444        .426        .405        .383       DATA 810
.360        .334        .308        .281        .254        .230       DATA 820
.216        .228        .260        .300        .369        .521       DATA 830
.653        .662        .609        .526        .435        .347       DATA 840
.267        .197        .136        .C834       .0347                  DATA 850
.520        .517        .513        .507        .498        .488       DATA 860
.475        .460        .444        .425        .405        .383       DATA 870
.359        .334        .308        .281        .254        .230       DATA 880
.216        .230        .262        .302        .368        .520       DATA 890
.653        .661        .609        .526        .435        .347       DATA 900
.267        .197        .136        .C836       .0349                  DATA 910
T                                                                      DATA 920
7U                                                                     DATA 930
-.495004728 -.350C21200  .350C21200 -.936741778 -.868890280 -.350021200DATA 940
-.350021200  .868890280 -.495004728 -.350C21200  .350021200 -.936741778DATA 950
-.868890280 -.350021200  .350C21200  .868890280                        DATA 960
-.868890280 -.868890280 -.868890280 -.350021200 -.350021200 -.350021200DATA 970
-.350021200 -.350C21200  .868890280  .868890280  .868890280  .350021200DATA 980
 .350021200  .350021200  .350C21200  .350C21200                        DATA 990
T                                                                      DATA1000
6U                                                                     DATA1010
0.0CC000000  .083333333  .083333333 0.CC0C00000  .083333333  .083333333DATA1020
 .083333333  .083333333 0.0CC0C0000  .083333333  .083333333 0.000000000DATA1030
 .083333333  .083333333  .083333333  .083333333                        DATA1040
T                                                                      DATA1050
1*           1.0        2R C.C      4*          19I 0.0     2118.273   DATA1060
11119.633    32.143                 5*          3R 1.0                 DATA1070
2*                                                                     DATA1080
    C.0          0.33        0.67        1.0                           DATA1090
8$                                                                     DATA1100
20R         1 3R        212R        3                                  DATA1110
20R         1 3R        212R        3                                  DATA1120
20R         1 3R        212R        3                                  DATA1130
9$                                                                     DATA1140
            -1          -5          -9                                 DATA1150
10$                     1           2           3           4         5DATA1160
            6           7           8           9           10       11DATA1170
            1211$       12R         C12*        12R 1.0                DATA1180
19$                                                                    DATA1190
            1           1           5           5           -9        9DATA1200
20$                                                                    DATA1210
            1           3           1           3           1         3DATA1220
T                                                                      DATA1230
```

TABLE 2-5

(Sheet 3 of 5)

```
   30000    5    6    1    2    8    3    4    0    0    0    0    0    0    0       DATA1240
 ROT SAMPLE PROBLEM NUMBER 2, 3 GROUP,S4,P3,R-Z,FIXED SOURCE CALCULATIONDATA1250
          13            0            3           16            1            3DATA1260
          35            3            0          0.0          0.0       0.0001DATA1270
           1            0            3            3            1            1DATA1280
          12           12           12            0            0            0DATA1290
           0          0.0            3            3            4            6DATA1300
         1.0            6            3          100            1          100DATA1310
         0.0       0.0002          0.0          0.0          0.0          0.0DATA1320
           0            8            8            2            2            0DATA1330
           0            0            3            0          0.0            0DATA1340
14*           .0013792     .0024645     .49223       .44107     2R 0.0     DATA1350
  .019753     .026816      1.2648       1.1946       .049779     0.0        DATA1360
  .17713      .30205       1.666        1.5C89       .050405     1.3637 -6DATA1370
 3R 0.0       .65001     5R 0.0         1.8407       .034195   5R 0.0       DATA1380
  .050124     4.9522 -9  3R 0.0         .53976    5R 0.0         1.2118     DATA1390
  -.015334  5R 0.0        -.047187     -7.782 -7 3R 0.0          .17245     DATA1400
 5R 0.0       .098833     -.082968   5R 0.0          -.082467   -2.1059-8DATA1410
  4.5227 -4   0.0          3.2087 -1   3.2015E-1 2R0.0           6.6839 -3DATA1420
  0.0         .78553       .77793       2.679  -4   0.0          .077168    DATA1430
  0.0         .98114       .90397       .0009081    0.0        3R0.0        DATA1440
  .18971    5R0.0          .089185     -1.073 -4 5R0.0          -4.8303-4DATA1450
  0.0       3R 0.0         .3179      5R 0.0         .048595    -1.338 -6DATA1460
 5R 0.0      -1.4316-5     0.0        3R 0.0          .1362    5R 0.0       DATA1470
  .027748     1.7342 -6  5R 0.0         3.9839 -6    0.0         1.8274 -4DATA1480
   0.0        .6095        .52306     2R0.0          7.6982 -4   0.0        DATA1490
  1.4654      1.3709       .086251      0.0          8.6944 -3   0.0        DATA1500
  1.7937      1.785        .093634      2.3664 -6 3R 0.0         .89753     DATA1510
 5R 0.0       2.5966       .055036   5R 0.0          .095594     7.9635 -9DATA1520
 3R 0.0       .67262     5R 0.0         1.7216       -.02761   5R 0.0       DATA1530
  -.046302   -1.3477-6   3R 0.0         .3191     5R 0.0         .158       DATA1540
  -4.3936-2 5R 0.0         -.14892     -1.0918-8  T                         DATA1550
 3*                                                                         DATA1560
    2.73        2.71         2.69         2.66         2.61         2.55    DATA1570
    2.49        2.41         2.32         2.23         2.12         2.00    DATA1580
    1.88        1.75         1.61         1.47         1.32         1.16    DATA1590
    1.00        .822         .671         .568         .468         .324    DATA1600
    .185        .108         .0623        .0361        .0211        .0121   DATA1610
    .00706      .00405       .00230       .00122       .000548              DATA1620
    2.73        2.72         2.69         2.66         2.61         2.56    DATA1630
    2.49        2.41         2.33         2.23         2.12         2.01    DATA1640
    1.88        1.75         1.61         1.47         1.32         1.16    DATA1650
    1.00        .825         .673         .568         .464         .319    DATA1660
    .182        .106         .0612        .0356        .0206        .0120   DATA1670
    .00689      .00401       .00224       .00122       .000512              DATA1680
    2.73        2.71         2.69         2.66         2.61         2.55    DATA1690
    2.49        2.41         2.32         2.23         2.12         2.00    DATA1700
    1.88        1.75         1.61         1.47         1.32         1.16    DATA1710
    1.00        .822         .671         .568         .468         .324    DATA1720
    .185        .108         .0623        .0361        .0211        .0121   DATA1730
    .00706      .00405       .00230       .00122       .000548              DATA1740
 T                                                                          DATA1750
 3*                                                                         DATA1760
    1.84        1.84         1.82         1.79         1.77         1.73    DATA1770
    1.68        1.63         1.57         1.51         1.44         1.36    DATA1780
    1.28        1.19         1.09         .994         .892         .786    DATA1790
    .678        .567         .482         .425         .373         .302    DATA1800
    .216        .147         .0969        .0623        .0396        .0247   DATA1810
    .0152       .00927       .00546       .00307       .00136               DATA1820
    1.84        1.83         1.82         1.80         1.77         1.73    DATA1830
    1.69        1.63         1.58         1.51         1.44         1.36    DATA1840
    1.28        1.19         1.09         .994         .892         .786    DATA1850
```

```
     .677       .568       .482       .425       .372       .301      DATA1860
     .216       .145       .0965      .0621      .0393      .0245     DATA1870
     .0152      .00921     .00544     .00304     .00133               DATA1880
     1.84       1.84       1.82       1.79       1.77       1.73      DATA1890
     1.68       1.63       1.57       1.51       1.44       1.36      DATA1900
     1.26       1.19       1.09       .994       .892       .786      DATA1910
     .678       .567       .482       .425       .373       .302      DATA1920
     .216       .147       .0969      .0623      .0396      .0247     DATA1930
     .0152      .00927     .00546     .00307     .00136               DATA1940
 T                                                                    DATA1950
 3*                                                                   DATA1960
     .520       .517       .513       .507       .498       .488      DATA1970
     .475       .460       .444       .425       .405       .383      DATA1980
     .359       .334       .308       .281       .254       .230      DATA1990
     .216       .230       .262       .302       .368       .520      DATA2000
     .653       .661       .609       .526       .435       .347      DATA2010
     .267       .197       .136       .0836      .0349                DATA2020
     .520       .518       .513       .507       .498       .488      DATA2030
     .475       .461       .444       .426       .405       .383      DATA2040
     .360       .334       .308       .281       .254       .230      DATA2050
     .216       .228       .260       .300       .369       .521      DATA2060
     .653       .662       .609       .526       .435       .347      DATA2070
     .267       .197       .136       .0834      .0347                DATA2080
     .520       .517       .513       .507       .498       .488      DATA2090
     .475       .460       .444       .425       .405       .383      DATA2100
     .359       .334       .308       .281       .254       .230      DATA2110
     .216       .230       .262       .302       .368       .520      DATA2120
     .653       .661       .609       .526       .435       .347      DATA2130
     .267       .197       .136       .0836      .0349                DATA2140
 T                                                                    DATA2150
17*                                                                   DATA2160
    1.0        0.0        0.0                                         DATA2170
 T                                                                    DATA2180
17*                                                                   DATA2190
     .21312     .21224     .21047     .20786     .20437     .20005    DATA2200
     .19487     .18889     .18207     .17451     .16617     .15716    DATA2210
     .14745     .13718     .12636     .11521     .10400     .093483   DATA2220
     .085866    .086223    0.         0.         0.         0.        DATA2230
     0.         0.         0.         0.         0.         0.        DATA2240
     0.         0.         0.         0.         0.                   DATA2250
 T                                                                    DATA2260
17*                                                                   DATA2270
    1.0        1.0        1.0                                         DATA2280
 T                                                                    DATA2290
 7U                                                                   DATA2300
 -.495004728 -.350021200  .350021200 -.936741778 -.868890280 -.350021200DATA2310
  .350021200  .868890280 -.495004728 -.350021200  .350021200 -.936741778DATA2320
 -.868890280 -.350021200  .350021200  .868890280                      DATA2330
 -.868890280 -.868890280 -.868890280 -.350021200 -.350021200 -.350021200DATA2340
 -.350021200 -.350021200  .868890280  .868890280  .868890280  .350021200DATA2350
  .350021200  .350021200  .350021200  .350021200                      DATA2360
 T                                                                    DATA2370
 6U                                                                   DATA2380
 0.000000000  .083333333  .083333333 0.000000000  .083333333  .083333333DATA2390
  .083333333  .083333333 0.000000000  .083333333  .083333333 0.000000000DATA2400
  .083333333  .083333333  .083333333  .083333333                      DATA2410
 T                                                                    DATA2420
 1*             0.0       2R 0.0      4*          19I 0.0     2118.273  DATA2430
11119.633       32.143                5*           3R 1.0               DATA2440
 2*                                                                   DATA2450
    0.0          0.33       0.67       1.0                            DATA2460
 8$                                                                   DATA2470
```

TABLE 2-5 (Sheet 5 of 5)

```
20R      1 3R     212R     3                                   DATA2480
20R      1 3R     212R     3                                   DATA2490
20R      1 3R     212R     3                                   DATA2500
 9$                                                            DATA2510
         -1       -5       -9                                  DATA2520
10$               1        2          3          4            5DATA2530
         6        7        8          9          10          11DATA2540
         1211$    12R      012*       12R 1.0                  DATA2550
.19$                                                           DATA2560
         1        1        5          5          9            9DATA2570
20$                                                            DATA2580
         1        3        1          3          1            3DATA2590
 T                                                             DATA2600
```

2.5 DESCRIPTION OF OUTPUT

Computer output from a DOT-IIW code calculation consists of printed output and two binary tapes. The following sections describe in detail each form of output.

2.5.1 Printout

Input Data Edit

The printed output from the sample problem input data presented in Section 2.4.5 is shown in Table 2-6.

The first part of the printed output is an edit of the input data. The following quantities are printed out.

(1) The title card at the top of the page.

(2) The parameters A01 through A15, IXBS, IMOLD, JMOLD, JMLEV, IDIR, ISIZE, NA, and NB.

(3) The value of LAST, the amount of variable dimension data storage locations used in the problem.

(4) As the data are read, the array name and the number of entries are printed. Beginning with Data Set 3, a T is printed at the end of each section of data.

(5) Zone numbers by interval, a two-dimensional map, with the minimum radius and height interval at the bottom left corner (8$).

(6) Material numbers by interval, a two-dimensional map, with the minimum radius and height interval at the bottom left corner.

(7) The S_n or angular quadrature constants. These are printed in nine columns across the page and contain the following information:

(a) The angle number.

(b) The angle weight (7* array)

$$\text{WEIGHT (M)} = \frac{1}{4\pi} \int d\Omega,$$

where the integration is over the solid angle represented by angle M.

3

TABLE 2-6

DOT SAMPLE PROBLEM NUMBER 1, 3 GROUP, S4, P3, R-Z, K-CALCULATION

DOT SAMPLE PROBLEM NUMBER 1, 3 GROUP,S4,P3,R-Z,K-CALCULATION

A01	PROBLEM ID NO.	13	A02	0/1 = REG./ADJ.	0
A03	ORDER OF SCATTERING	3	A04	NUMBER OF ANGLES	16
IGE	0/1/2 = X-Y/R-Z/R-T	1	IZM	NO. OF MATERIAL ZONES	3
IM	NO. OF RADIAL INT.	39	JM	NO. OF AXIAL INT.	3
I04	0/1/2/3/4/5=Q/K/ALPHA/C/Z/BQ	1	EV	EIGENVALUE GUESS	0.
EVM	EIGENVALUE MODIFIER	0.	EPS	PRECISION DESIRED	1.00000E-04
B01	LEFT BOUNDARY CONDITION	1	B02	RIGHT BOUNDARY CONDITION	0
B03	TOP BOUNDARY CONDITION	3	B04	BOTTOM BOUNDARY CONDITION	3
M07	FLUX INPUT TRIGGER	1	MODE	FLUX CALCULATION MODE	1
MT	NO. OF MATERIALS	12	M01	MIXING TABLE LENGTH	12
MCR	NO. MATLS. FROM CARDS	12	MTP	NO. MATLS. FROM LIB TAPE	0
IZ	NO. RADIAL SEARCH ZONES	0	JZ	NO. AXIAL SEARCH ZONES	0
S02	0/1/2=NONE/K/ALPHA	0	S03	PARAM. EIGEN.-SEARCH	0.
IGM	NO. OF ENERGY GROUPS	3	IHT	POSITION OF SIGMA T	3
IHS	POSITION OF SIGMA GG	4	ITL	TABLE LENGTH	6
S01	NORMALIZATION FACTOR	1.00000E+00	M05	0/N=NO/N ACT. BY ZONE	6
M06	DISTR. SOURCE INPUT TRIGGER	0	S04	INITIAL INNER ITER. MAX.	30
G05	OUTER ITER. MAX.	20	G07	INNER ITER. MAX.	30
G05	NEUTRON BALANCE EPS.	0.	G06	POINTWISE FLUX EPS.	2.00000E-04
LAL	SEARCH EPSILON	0.	LAH	1-LAMBDA MAX.-SEARCH	0.
POD	PAR. OSC. DAMP-SEARCH	0.	EPSA	NEW PAR. EPS.-SEARCH	0.
IAFT	ANG. FLUX OUTPUT TRIGGER	0	A05	NO. OF +ETA ANGLES	8
A06	NO. OF -ETA ANGLES	8	A07	NO. OF +ETA INIT. DIRECTIONS	2
A08	NO. OF -ETA INIT. DIRECTIONS	2	A09	0/1/2/3=NORMAL/SOR/SPS/CA	0
A10	0/N=ALL/N ZONES OF CONVERGENCE	0	A11	0/N=ALL/NTH INTERVAL ANG FLUXES	0
A12	NO. OF NEUTRON GROUPS	3	A13	0/1=PRINT X-SEC/DO NOT	0
A14	UPSCATTER EPSILON	1.00000E-04	A15	ENTER ZERO	0
IXBS	0/1/2/3=NO/TOP/RIGHT/BOTH-TAPE	0	IMOLD	NO. OLD RADIAL INT.	0
JMOLD	NO. OLD AXIAL INT.	0	JMLEV	AXIAL ROW FOR BNDRY SOURCE	0
IDIR	0/1=UP/DOWN DIRECTION	0	NA	STARTING INTVL,BNDRY SOURCE	0
NC	FINAL INTVL,BNDRY SOURCE	0	ISIZE	AVAILABLE CORE DATA STORAGE	30000

6208 LOCATIONS WILL BE USED FOR THIS PROBLEM

TABLE 2-6 (Continued)

```
 14* ARRAY  216 ENTRIES READ
   T
  3* ARRAY  105 ENTRIES READ
   T
  3* ARRAY  105 ENTRIES READ
   T
  3* ARRAY  105 ENTRIES READ
   T
NON-STANDARD INPUT FORMAT USED
  7U ARRAY   32 ENTRIES READ
   T
NON-STANDARD INPUT FORMAT USED
  6U ARRAY   16 ENTRIES READ
   T
  1* ARRAY    3 ENTRIES READ
  4* ARRAY   36 ENTRIES READ
  5* ARRAY    3 ENTRIES READ
  2* ARRAY    4 ENTRIES READ
  8$ ARRAY  105 ENTRIES READ
  9$ ARRAY    3 ENTRIES READ
 10$ ARRAY   12 ENTRIES READ
 11$ ARRAY   12 ENTRIES READ
```

TABLE 2-6 (Continued)

```
12* ARRAY   12 ENTRIES READ
15$ ARRAY    6 ENTRIES READ
20$ ARRAY    6 ENTRIES READ
  T
```

TABLE 2-6 (Continued)

```
                    REGICN DESCRIPTICN BY INTERVAL
 XRR
Y
Z
T
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 3 3 3 3 3 3 3 3 3 3 3 3
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 3 3 3 3 3 3 3 3 3 3 3 3
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 3 3 3 3 3 3 3 3 3 3 3 3
```

TABLE 2-6 (Continued)

```
                    MATERIAL DESCRIPTION BY INTERVAL
 XRR
Y
Z
T
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 5 5 5 9 9 9 9 9 9 9 9 9 9 9 9
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 5 5 5 9 9 9 9 9 9 9 9 9 9 9 9
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 5 5 5 9 9 9 9 9 9 9 9 9 9 9 9
```

TABLE 2-6 (Continued)

I	WEIGHT	ETA	MU	MU * WT	ETA * WT	M3
1	0.	-0.86889028E+00	-0.49500473E+00	0.	0.	0.
2	0.83333333E-01	-0.86889028E+00	-0.35002120E+00	-0.29168433E-01	-0.72407523E-01	0.35002120E+00
3	0.83333333E-01	-0.86889028E+00	0.35002120E+00	0.29168433E-01	-0.72407523E-01	0.35002120E+00
4	0.	-0.35002120E+00	-0.93674178E+00	0.	0.	0.
5	0.83333333E-01	-0.35002120E+00	-0.86889028E+00	-0.72407523E-01	-0.29168433E-01	0.86889028E+00
6	0.83333333E-01	-0.35002120E+00	-0.35002120E+00	-0.29168433E-01	-0.29168433E-01	0.20878018E+01
7	0.83333333E-01	-0.35002120E+00	0.35002120E+00	0.29168433E-01	-0.29168433E-01	0.20878018E+01
8	0.83333333E-01	-0.35002120E+00	0.86889028E+00	0.72407523E-01	-0.29168433E-01	0.86889028E+00
9	0.	0.86889028E+00	-0.49500473E+00	0.	0.	0.
10	0.83333333E-01	0.86889028E+00	-0.35002120E+00	-0.29168433E-01	0.72407523E-01	0.35002120E+00
11	0.83333333E-01	0.86889028E+00	0.35002120E+00	0.29168433E-01	0.72407523E-01	0.35002120E+00
12	0.	0.35002120E+00	-0.93674178E+00	0.	0.	0.
13	0.83333333E-01	0.35002120E+00	-0.86889028E+00	-0.72407523E-01	0.29168433E-01	0.86889028E+00
14	0.83333333E-01	0.35002120E+00	-0.35002120E+00	-0.29168433E-01	0.29168433E-01	0.20878018E+01
15	0.83333333E-01	0.35002120E+00	0.35002120E+00	0.29168433E-01	0.29168433E-01	0.20878018E+01
16	0.83333333E-01	0.35002120E+00	0.86889028E+00	0.72407523E-01	0.29168433E-01	0.86889028E+00

TABLE 2-6 (Continued)

DISCRETE VALUES OF PLM(THETA)*COS(M*PSI)

ANGL	PLMC 1	PLMC 2	PLMC 3	PLMC 4	PLMC 5	PLMC 6	PLMC 7	PLMC 8
1	-4.95005E-01	-8.68890E-01	-1.32455E-01	7.44963E-01	6.53823E-01	4.39280E-01	-1.19798E-01	-7.23694E-01
2	-3.50021E-01	-8.68890E-01	-3.16228E-01	5.26769E-01	5.47723E-01	4.17825E-01	2.06143E-01	-4.28687E-01
3	3.50021E-01	-8.68890E-01	-3.16228E-01	-5.26769E-01	5.47723E-01	-4.17825E-01	2.06143E-01	4.28687E-01
4	-9.36742E-01	-3.50021E-01	8.16228E-01	5.67904E-01	1.06101E-01	-6.49830E-01	-7.26072E-01	-2.22241E-01
5	-8.68890E-01	-3.50021E-01	6.32455E-01	5.26769E-01	0.	-3.36631E-01	-5.94771E-01	0.
6	-3.50021E-01	-3.50021E-01	-3.16228E-01	2.12202E-01	-5.47722E-01	4.17825E-01	8.30421E-02	-4.28687E-01
7	3.50021E-01	-3.50021E-01	-3.16228E-01	-2.12202E-01	-5.47722E-01	-4.17825E-01	8.30421E-02	-4.28687E-01
8	8.68890E-01	-3.50021E-01	6.32455E-01	-5.26769E-01	0.	3.36631E-01	-5.94771E-01	0.
9	-4.95005E-01	8.68890E-01	-1.32455E-01	-7.44963E-01	6.53823E-01	4.39280E-01	1.19798E-01	-7.23694E-01
10	-3.50021E-01	8.68890E-01	-3.16228E-01	-5.26769E-01	5.47723E-01	-4.17825E-01	-2.06143E-01	-4.28687E-01
11	3.50021E-01	8.68890E-01	-3.16228E-01	5.26769E-01	5.47723E-01	-4.17825E-01	-2.06143E-01	4.28687E-01
12	-9.36742E-01	3.50021E-01	8.16228E-01	-5.67904E-01	1.06101E-01	-6.49830E-01	7.26072E-01	-2.22241E-01
13	-8.68890E-01	3.50021E-01	6.32455E-01	-5.26769E-01	0.	-3.36631E-01	5.94771E-01	0.
14	-3.50021E-01	3.50021E-01	-3.16228E-01	-2.12202E-01	-5.47723E-01	4.17825E-01	-8.30421E-02	4.28687E-01
15	3.50021E-01	3.50021E-01	-3.16228E-01	2.12202E-01	-5.47723E-01	-4.17825E-01	-8.30421E-02	-4.28687E-01
16	8.68890E-01	3.50021E-01	6.32455E-01	5.26769E-01	0.	3.36631E-01	5.94771E-01	0.

ANGL	PLMC 9
1	-5.18603E-01
2	-2.66130E-01
3	-2.66130E-01
4	-3.39018E-02
5	6.78036E-02
6	5.92835E-01
7	5.92835E-01
8	6.78036E-02
9	5.18603E-01
10	2.66130E-01
11	2.66130E-01
12	3.39018E-02
13	-6.78036E-02
14	-5.92835E-01
15	-5.92835E-01
16	-6.78036E-02

TABLE 2-6 (Continued)

CROSS-SECTION EDIT

GROUP 1 CROSS-SECTIONS

POS.	MAT. 1	MAT. 2	MAT. 3	MAT. 4	MAT. 5	MAT. 6	MAT. 7	MAT. 8
1	1.37920E-03	0.	0.	0.	4.52270E-04	0.	0.	0.
2	2.46450E-03	0.	0.	0.	0.	0.	0.	0.
3	4.92230E-01	0.	0.	0.	3.20870E-01	0.	0.	0.
4	4.41070E-01	6.50010E-01	5.39760E-01	1.72460E-01	3.20150E-01	1.89710E-01	3.17900E-01	1.36200E-01
5	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.

POS.	MAT. 9	MAT. 10	MAT. 11	MAT. 12
1	1.82740E-04	0.	0.	0.
2	0.	0.	0.	0.
3	6.09500E-01	0.	0.	0.
4	5.23060E-01	8.97530E-01	6.72620E-01	3.19100E-01
5	0.	0.	0.	0.
6	0.	0.	0.	0.

GROUP 2 CROSS-SECTIONS

POS.	MAT. 1	MAT. 2	MAT. 3	MAT. 4	MAT. 5	MAT. 6	MAT. 7	MAT. 8
1	1.97530E-02	0.	0.	0.	6.68390E-03	0.	0.	0.
2	2.68160E-02	0.	0.	0.	0.	0.	0.	0.
3	1.26480E+00	0.	0.	0.	7.85530E-01	0.	0.	0.
4	1.19460E+00	1.84070E+00	1.21180E+00	9.88330E-02	7.77930E-01	8.91850E-02	4.85950E-02	2.77480E-02
5	4.97790E-02	3.41950E-02	-1.53340E-02	-8.29680E-02	2.67900E-04	-1.07300E-04	-1.33800E-06	1.73420E-06
6	0.	0.	0.	0.	0.	0.	0.	0.

POS.	MAT. 9	MAT. 10	MAT. 11	MAT. 12
1	7.69820E-04	0.	0.	0.
2	0.	0.	0.	0.
3	1.46540E+00	0.	0.	0.
4	1.37090E+00	2.59660E+00	1.72160E+00	1.58000E-01
5	8.62510E-02	5.50360E-02	-2.76100E-02	-4.39360E-02
6	0.	0.	0.	0.

GROUP 3 CROSS-SECTIONS

POS.	MAT. 1	MAT. 2	MAT. 3	MAT. 4	MAT. 5	MAT. 6	MAT. 7	MAT. 8
1	1.77130E-01	0.	0.	0.	7.71680E-02	0.	0.	0.
2	3.02050E-01	0.	0.	0.	0.	0.	0.	0.
3	1.68600E+00	0.	0.	0.	9.81140E-01	0.	0.	0.
4	1.50890E+00	0.	0.	0.	9.03970E-01	0.	0.	0.

TABLE 2-6 (Continued)

5	5.04050E-02	5.01240E-02	-4.71870E-02	-8.24670E-02	9.08100E-04	-4.83030E-04	-1.43160E-05	3.98390E-06
6	1.36370E-06	4.95220E-09	-7.78200E-07	-2.10590E-08	0.	0.	0.	0.

POS.	MAT. 9	MAT. 10	MAT. 11	MAT. 12
1	8.69440E-03	0.	0.	0.
2	0.	0.	0.	0.
3	1.79370E+00	0.	0.	0.
4	1.78500E+00	0.	0.	0.
5	9.36340E-02	5.55940E-02	-4.63020E-02	-1.48920E-01
6	2.36640E-06	7.96350E-09	-1.34770E-06	-1.09180E-08

TABLE 2-6 (Continued)

	MIXTURE	SUM	COMPONENT	DENSITY	RADIUS	R MIDPOINT	HEIGHT	H MIDPOINT	MAT. BY ZONE
1	1		0	1.00000E+00	0	4.56825E-01	0	1.65000E-01	-1
2	2		0	1.00000E+00	9.13650E-01	1.37047E+00	3.30000E-01	5.00000E-01	-5
3	3		0	1.00000E+00	1.82730E+00	2.28412E+00	6.70000E-01	8.35000E-01	-9
4	4		0	1.00000E+00	2.74095E+00	3.19777E+00	1.00000E+00		
5	5		0	1.00000E+00	3.65460E+00	4.11142E+00			
6	6		0	1.00000E+00	4.56825E+00	5.02507E+00			
7	7		0	1.00000E+00	5.48190E+00	5.93872E+00			
8	8		0	1.00000E+00	6.39555E+00	6.85237E+00			
9	9		0	1.00000E+00	7.30920E+00	7.76602E+00			
10	10		0	1.00000E+00	8.22285E+00	8.67967E+00			
11	11		0	1.00000E+00	9.13650E+00	9.59332E+00			
12	12		0	1.00000E+00	1.00501E+01	1.05070E+01			
13					1.09638E+01	1.14206E+01			
14					1.18774E+01	1.23343E+01			
15					1.27911E+01	1.32479E+01			
16					1.37047E+01	1.41616E+01			
17					1.46184E+01	1.50752E+01			
18					1.55320E+01	1.59889E+01			
19					1.64457E+01	1.69025E+01			
20					1.73593E+01	1.78162E+01			
21					1.82730E+01	1.84997E+01			
22					1.87263E+01	1.89530E+01			
23					1.91797E+01	1.94063E+01			
24					1.96330E+01	2.01542E+01			
25					2.06755E+01	2.11967E+01			
26					2.17180E+01	2.22392E+01			
27					2.27605E+01	2.32817E+01			
28					2.38030E+01	2.43243E+01			
29					2.48455E+01	2.53667E+01			
30					2.58880E+01	2.64092E+01			
31					2.69305E+01	2.74517E+01			
32					2.79730E+01	2.84942E+01			
33					2.90155E+01	2.95367E+01			
34					3.00580E+01	3.05792E+01			
35					3.11005E+01	3.16217E+01			
36					3.21430E+01				

	FIS. SPECTRUM	VELOCITY
1	1.00000E+00	1.00000E+00
2	0	1.00000E+00
3	0	1.00000E+00

TABLE 2-6 (Continued)

```
FLUX  1 LC  0 II    0 NB  0.           USF 0.            EQ  0.          EV  0.                LA  0.
   GROUP    1 INNER ITERATIONS =  30 FLUX ERROR MAX =  1.87271E-02   AT ( 35,  2)
   GROUP    2 INNER ITERATIONS =  30 FLUX ERROR MAX =  1.26652E-03   AT ( 35,  2)
   GROUP    3 INNER ITERATIONS =  30 FLUX ERROR MAX =  2.35581E-03   AT ( 15,  3)
FLUX  2 LC  1 II   90 NB  9.999999E-01 USF 0.            EQ  0.          EV  1.446767E+00  LA  1.44676720E+00
   GROUP    1 INNER ITERATIONS =  30 FLUX ERROR MAX =  6.00869E-04   AT ( 35,  2)
   GROUP    2 INNER ITERATIONS =  30 FLUX ERROR MAX =  1.04075E-03   AT ( 35,  3)
   GROUP    3 INNER ITERATIONS =  30 FLUX ERROR MAX =  1.24620E-03   AT ( 15,  3)
FLUX  1 LC  2 II   90 NB  9.999999E-01 USF 0.            EQ  0.          EV  1.437010E+00  LA  9.93255725E-01
   GROUP    1 INNER ITERATIONS =   9 FLUX ERROR MAX =  1.93229E-04   AT (  1,  3)
   GROUP    2 INNER ITERATIONS =  25 FLUX ERROR MAX =  1.85842E-04   AT ( 35,  3)
   GROUP    3 INNER ITERATIONS =  30 FLUX ERROR MAX =  7.98671E-04   AT ( 34,  3)
FLUX  2 LC  3 II   64 NB  9.999999E-01 USF 0.            EQ  0.          EV  1.431926E+00  LA  9.96462134E-01
   GROUP    1 INNER ITERATIONS =   6 FLUX ERROR MAX =  1.97567E-04   AT (  1,  3)
   GROUP    2 INNER ITERATIONS =   1 FLUX ERROR MAX =  1.53615E-04   AT ( 35,  3)
   GROUP    3 INNER ITERATIONS =  30 FLUX ERROR MAX =  7.00033E-04   AT ( 35,  3)
FLUX  1 LC  4 II   37 NB  9.999999E-01 USF 0.            EQ  0.          EV  1.429053E+00  LA  9.97993515E-01
   GROUP    1 INNER ITERATIONS =   3 FLUX ERROR MAX =  1.73557E-04   AT ( 35,  2)
   GROUP    2 INNER ITERATIONS =   1 FLUX ERROR MAX =  1.44115E-04   AT (  1,  1)
   GROUP    3 INNER ITERATIONS =  30 FLUX ERROR MAX =  5.57708E-04   AT ( 35,  3)
FLUX  2 LC  5 II   34 NB  9.999999E-01 USF 0.            EQ  0.          EV  1.427375E+00  LA  9.98826187E-01
   GROUP    1 INNER ITERATIONS =   1 FLUX ERROR MAX =  1.87281E-04   AT ( 35,  2)
   GROUP    2 INNER ITERATIONS =   1 FLUX ERROR MAX =  1.42554E-04   AT (  1,  3)
   GROUP    3 INNER ITERATIONS =  30 FLUX ERROR MAX =  4.13151E-04   AT ( 35,  3)
FLUX  1 LC  6 II   32 NB  9.999999E-01 USF 0.            EQ  0.          EV  1.426387E+00  LA  9.99307624E-01
   GROUP    1 INNER ITERATIONS =   1 FLUX ERROR MAX =  1.56657E-04   AT ( 25,  2)
   GROUP    2 INNER ITERATIONS =   1 FLUX ERROR MAX =  1.39575E-04   AT (  1,  3)
   GROUP    3 INNER ITERATIONS =  30 FLUX ERROR MAX =  2.90641E-04   AT ( 35,  3)
FLUX  2 LC  7 II   32 NB  9.999999E-01 USF 0.            EQ  0.          EV  1.425801E+00  LA  9.99589301E-01
   GROUP    1 INNER ITERATIONS =   1 FLUX ERROR MAX =  1.55001E-04   AT ( 26,  2)
   GROUP    2 INNER ITERATIONS =   1 FLUX ERROR MAX =  1.36559E-04   AT (  1,  3)
   GROUP    3 INNER ITERATIONS =  29 FLUX ERROR MAX =  1.99669E-04   AT ( 35,  3)
FLUX  1 LC  8 II   31 NB  9.999999E-01 USF 0.            EQ  0.          EV  1.425463E+00  LA  9.99762395E-01
   GROUP    1 INNER ITERATIONS =   1 FLUX ERROR MAX =  1.53131E-04   AT ( 26,  2)
   GROUP    2 INNER ITERATIONS =   1 FLUX ERROR MAX =  1.33793E-04   AT (  1,  3)
   GROUP    3 INNER ITERATIONS =   1 FLUX ERROR MAX =  1.97117E-04   AT ( 35,  3)
```

TABLE 2-6 (Continued)

BALANCE TABLE SUMMARY

GROUP	FIXED SO	FISSION SO	IN-SCATTER	SELF-SCATTER	HZ-LEAKAGE	ABSORPTIONS	OUT-SCATTER	RT-LEAKAG
1	0.	1.00000E+00	-3.55271E-15	8.66825E+00	3.27177E-04	2.50895E-02	9.74583E-01	3.27177E-0
2	0.	0.	9.74545E-01	1.67028E+01	6.73453E-04	2.43696E-01	7.30177E-01	6.73453E-0
3	0.	0.	7.29567E-01	1.78543E+01	1.21070E-02	7.17531E-01	-6.60970E-05	1.21070E-0
4	0.	1.00000E+00	1.70411E+00	4.32254E+01	1.31077E-02	9.86316E-01	1.70469E+00	1.31077E-0

GROUP	VT-LEAKAGE	TOP-LEAKAGE	NET-LEAKAGE	BALANCE
1	-2.09672E-07	-2.09672E-07	3.26967E-04	1.00000E+00
2	-6.31759E-07	-6.31759E-07	6.72821E-04	1.00000E+00
3	-4.46770E-06	-4.46770E-06	1.21026E-02	1.00000E+00
4	-5.30913E-06	-5.30913E-06	1.31024E-02	1.00000E+00

FLUX 2 LC 9 II 3 NB 9.999999E-01 USF 0. EQ 0. EV 1.425455E+00 LA 9.99994215E-01

TABLE 2-6 (Continued)

I	RADIUS	R MIDPOINT	HEIGHT	H MIDPOINT
1	0.	4.5682500E-01	0.	1.6500000E-01
2	9.1365000E-01	1.3704750E+00	3.3000000E-01	5.0000000E-01
3	1.8273000E+00	2.2841250E+00	6.7000000E-01	8.3500000E-01
4	2.7409500E+00		1.0000000E+00	
		3.1977750E+00		
5	3.6546000E+00	4.1114250E+00		
6	4.5682500E+00	5.0250750E+00		
7	5.4819000E+00	5.9387250E+00		
8	6.3955500E+00	6.8523750E+00		
9	7.3092000E+00	7.7660250E+00		
10	8.2228500E+00	8.6796750E+00		
11	9.1365000E+00	9.5933250E+00		
12	1.0050150E+01	1.0506975E+01		
13	1.0963800E+01	1.1420625E+01		
14	1.1877450E+01	1.2334275E+01		
15	1.2791100E+01	1.3247925E+01		
16	1.3704750E+01	1.4161575E+01		
17	1.4618400E+01	1.5075225E+01		
18	1.5532050E+01	1.5988875E+01		
19	1.6445700E+01	1.6902525E+01		
20	1.7359350E+01	1.7816175E+01		
21	1.8273000E+01	1.8499667E+01		
22	1.8726333E+01	1.8953000E+01		
23	1.9179667E+01	1.9406333E+01		
24	1.9633000E+01	2.0154250E+01		
25	2.0675500E+01	2.1196750E+01		
26	2.1718000E+01	2.2239250E+01		
27	2.2760500E+01	2.3281750E+01		
28	2.3803000E+01	2.4324250E+01		
29	2.4845500E+01	2.5366750E+01		
30	2.5888000E+01	2.6409250E+01		
31	2.6930500E+01	2.7451750E+01		
32	2.7973000E+01	2.8494250E+01		
33	2.9015500E+01	2.9536750E+01		
34	3.0058000E+01	3.0579250E+01		
35	3.1100500E+01	3.1621750E+01		
36	3.2143000E+01			

TABLE 2-6 (Continued)

FLUX FOR GROUP 1

XRR	YZT= 1	YZT= 2	YZT= 3
1	2.7911E-02	2.7933E-02	2.7911E-02
2	2.7781E-02	2.7804E-02	2.7781E-02
3	2.7530E-02	2.7552E-02	2.7530E-02
4	2.7156E-02	2.7178E-02	2.7156E-02
5	2.6662E-02	2.6684E-02	2.6662E-02
6	2.6050E-02	2.6071E-02	2.6050E-02
7	2.5323E-02	2.5344E-02	2.5323E-02
8	2.4485E-02	2.4505E-02	2.4485E-02
9	2.3541E-02	2.3561E-02	2.3541E-02
10	2.2498E-02	2.2516E-02	2.2498E-02
11	2.1360E-02	2.1378E-02	2.1360E-02
12	2.0136E-02	2.0153E-02	2.0136E-02
13	1.8833E-02	1.8850E-02	1.8833E-02
14	1.7461E-02	1.7476E-02	1.7461E-02
15	1.6029E-02	1.6043E-02	1.6029E-02
16	1.4548E-02	1.4559E-02	1.4548E-02
17	1.3022E-02	1.3035E-02	1.3022E-02
18	1.1454E-02	1.1470E-02	1.1454E-02
19	9.8473E-03	9.8654E-03	9.8473E-03
20	8.0625E-03	8.0956E-03	8.0625E-03
21	6.5754E-03	6.5990E-03	6.5753E-03
22	5.5658E-03	5.5611E-03	5.5657E-03
23	4.5774E-03	4.5379E-03	4.5774E-03
24	3.1748E-03	3.1259E-03	3.1747E-03
25	1.8033E-03	1.7757E-03	1.8032E-03
26	1.0558E-03	1.0342E-03	1.0558E-03
27	6.0661E-04	5.9605E-04	6.0660E-04
28	3.5085E-04	3.4590E-04	3.5085E-04
29	2.0451E-04	1.9962E-04	2.0451E-04
30	1.1766E-04	1.1646E-04	1.1766E-04
31	6.8474E-05	6.6767E-05	6.8473E-05
32	3.9266E-05	3.8870E-05	3.9266E-05
33	2.2259E-05	2.1662E-05	2.2259E-05
34	1.1842E-05	1.1798E-05	1.1842E-05
35	5.2991E-06	4.9570E-06	5.2991E-06

TABLE 2-6 (Continued)

FLUX FOR GROUP 2

XRR	YZT= 1	YZT= 2	YZT= 3
1	1.8942E-02	1.8948E-02	1.8942E-02
2	1.8855E-02	1.8862E-02	1.8855E-02
3	1.8686E-02	1.8692E-02	1.8686E-02
4	1.8434E-02	1.8440E-02	1.8433E-02
5	1.8100E-02	1.8106E-02	1.8100E-02
6	1.7686E-02	1.7692E-02	1.7686E-02
7	1.7195E-02	1.7201E-02	1.7195E-02
8	1.6628E-02	1.6634E-02	1.6628E-02
9	1.5990E-02	1.5995E-02	1.5990E-02
10	1.5283E-02	1.5288E-02	1.5283E-02
11	1.4512E-02	1.4517E-02	1.4512E-02
12	1.3681E-02	1.3686E-02	1.3681E-02
13	1.2795E-02	1.2800E-02	1.2796E-02
14	1.1861E-02	1.1865E-02	1.1861E-02
15	1.0883E-02	1.0887E-02	1.0883E-02
16	9.8687E-03	9.8721E-03	9.8688E-03
17	8.8221E-03	8.8256E-03	8.8222E-03
18	7.7508E-03	7.7545E-03	7.7508E-03
19	6.6647E-03	6.6647E-03	6.6647E-03
20	5.5643E-03	5.5691E-03	5.5642E-03
21	4.7156E-03	4.7225E-03	4.7156E-03
22	4.1549E-03	4.1526E-03	4.1549E-03
23	3.6420E-03	3.6300E-03	3.6419E-03
24	2.9440E-03	2.9354E-03	2.9440E-03
25	2.1004E-03	2.0998E-03	2.1004E-03
26	1.4266E-03	1.4216E-03	1.4266E-03
27	9.4081E-04	9.3687E-04	9.4080E-04
28	6.0412E-04	6.0176E-04	6.0411E-04
29	3.8291E-04	3.8084E-04	3.8291E-04
30	2.3885E-04	2.3759E-04	2.3885E-04
31	1.4719E-04	1.4645E-04	1.4718E-04
32	8.9528E-05	8.8890E-05	8.9528E-05
33	5.2708E-05	5.2503E-05	5.2708E-05
34	2.9549E-05	2.9338E-05	2.9549E-05
35	1.3120E-05	1.2808E-05	1.3120E-05

TABLE 2-6 (Continued)

FLUX FOR GROUP 3

XRR	YZT= 1	YZT= 2	YZT= 3
1	5.3418E-03	5.3422E-03	5.3418E-03
2	5.3174E-03	5.3181E-03	5.3174E-03
3	5.2697E-03	5.2700E-03	5.2697E-03
4	5.1983E-03	5.1991E-03	5.1984E-03
5	5.1042E-03	5.1045E-03	5.1043E-03
6	4.9872E-03	4.9881E-03	4.9873E-03
7	4.8487E-03	4.8488E-03	4.8487E-03
8	4.6885E-03	4.6894E-03	4.6886E-03
9	4.5085E-03	4.5085E-03	4.5085E-03
10	4.3087E-03	4.3096E-03	4.3088E-03
11	4.0913E-03	4.0914E-03	4.0913E-03
12	3.8569E-03	3.8576E-03	3.8569E-03
13	3.6074E-03	3.6075E-03	3.6074E-03
14	3.3447E-03	3.3453E-03	3.3448E-03
15	3.0715E-03	3.0716E-03	3.0716E-03
16	2.7923E-03	2.7927E-03	2.7923E-03
17	2.5181E-03	2.5179E-03	2.5181E-03
18	2.2721E-03	2.2704E-03	2.2722E-03
19	2.1207E-03	2.1209E-03	2.1208E-03
20	2.2500E-03	2.2323E-03	2.2501E-03
21	2.5553E-03	2.5318E-03	2.5554E-03
22	2.9374E-03	2.9232E-03	2.9375E-03
23	3.5762E-03	3.5877E-03	3.5762E-03
24	5.0505E-03	5.0601E-03	5.0506E-03
25	6.3375E-03	6.3418E-03	6.3377E-03
26	6.4104E-03	6.4182E-03	6.4105E-03
27	5.9002E-03	5.9010E-03	5.9003E-03
28	5.0926E-03	5.0932E-03	5.0926E-03
29	4.2150E-03	4.2159E-03	4.2150E-03
30	3.3665E-03	3.3650E-03	3.3664E-03
31	2.5962E-03	2.5968E-03	2.5960E-03
32	1.9215E-03	1.9197E-03	1.9214E-03
33	1.3288E-03	1.3299E-03	1.3286E-03
34	8.1677E-04	8.1551E-04	8.1669E-04
35	3.4228E-04	3.4014E-04	3.4225E-04

TABLE 2-6 (Continued)

FISSION EDIT

XRR	YZT= 1	YZT= 2	YZT= 3
1	2.1902E-03	2.1906E-03	2.1902E-03
2	2.1802E-03	2.1806E-03	2.1802E-03
3	2.1606E-03	2.1610E-03	2.1606E-03
4	2.1314E-03	2.1319E-03	2.1314E-03
5	2.0928E-03	2.0931E-03	2.0928E-03
6	2.0449E-03	2.0453E-03	2.0449E-03
7	1.9880E-03	1.9883E-03	1.9881E-03
8	1.9224E-03	1.9229E-03	1.9224E-03
9	1.8486E-03	1.8488E-03	1.8486E-03
10	1.7667E-03	1.7672E-03	1.7667E-03
11	1.6776E-03	1.6778E-03	1.6776E-03
12	1.5815E-03	1.5819E-03	1.5815E-03
13	1.4791E-03	1.4793E-03	1.4792E-03
14	1.3714E-03	1.3717E-03	1.3714E-03
15	1.2591E-03	1.2593E-03	1.2591E-03
16	1.1439E-03	1.1441E-03	1.1439E-03
17	1.0293E-03	1.0293E-03	1.0293E-03
18	9.2237E-04	9.2198E-04	9.2238E-04
19	8.4355E-04	8.4367E-04	8.4357E-04
20	8.4870E-04	8.4357E-04	8.4871E-04
21	0.	0.	0.
22	0.	0.	0.
23	0.	0.	0.
24	0.	0.	0.
25	0.	0.	0.
26	0.	0.	0.
27	0.	0.	0.
28	0.	0.	0.
29	0.	0.	0.
30	0.	0.	0.
31	0.	0.	0.
32	0.	0.	0.
33	0.	0.	0.
34	0.	0.	0.
35	0.	0.	0.

TABLE 2-6 (Continued)

ACTIVITY	MATERIAL	POSITION
1	1	1
2	1	3
3	5	1
4	5	3
5	-9	1
6	9	3

TABLE 2-6 (Continued)

ACTIVITY 0 PLUS N

N 1

XRR	YZT 1	YZT 2	YZT 3
1	1.35885E-03	1.35908E-03	1.35885E-03
2	1.35263E-03	1.35291E-03	1.35263E-03
3	1.34049E-03	1.34071E-03	1.34049E-03
4	1.32235E-03	1.32264E-03	1.32236E-03
5	1.29841E-03	1.29861E-03	1.29842E-03
6	1.26867E-03	1.26897E-03	1.26868E-03
7	1.23342E-03	1.23359E-03	1.23343E-03
8	1.19270E-03	1.19300E-03	1.19271E-03
9	1.14689E-03	1.14704E-03	1.14691E-03
10	1.09612E-03	1.09640E-03	1.09613E-03
11	1.04079E-03	1.04093E-03	1.04081E-03
12	9.81174E-04	9.81426E-04	9.81189E-04
13	9.17694E-04	9.17834E-04	9.17710E-04
14	8.50820E-04	8.51025E-04	8.50835E-04
15	7.81136E-04	7.812[illegible]5E-04	7.81151E-04
16	7.09596E-04	7.09748E-04	7.09608E-04
17	6.38253E-04	6.38304E-04	6.38264E-04
18	5.71359E-04	5.71145E-04	5.71367E-04
19	5.20873E-04	5.20938E-04	5.20880E-04
20	5.19577E-04	5.16587E-04	5.19583E-04
21	0.	0.	0.

XRR 22 THRU XRR 35 SAME AS ABOVE

N 2

XRR	YZT 1	YZT 2	YZT 3
1	4.67034E-02	4.67222E-02	4.67026E-02
2	4.64884E-02	4.65085E-02	4.64876E-02
3	4.60698E-02	4.60892E-02	4.60691E-02
4	4.54467E-02	4.54664E-02	4.54460E-02
5	4.46226E-02	4.46414E-02	4.46220E-02
6	4.36007E-02	4.36201E-02	4.36003E-02
7	4.23876E-02	4.24055E-02	4.23873E-02
8	4.09886E-02	4.10072E-02	4.09885E-02
9	3.94128E-02	3.94296E-02	3.94128E-02
10	3.76682E-02	3.76856E-02	3.76683E-02
11	3.57660E-02	3.57816E-02	3.57663E-02
12	3.37174E-02	3.37332E-02	3.37178E-02
13	3.15358E-02	3.15499E-02	3.15363E-02
14	2.92359E-02	2.92493E-02	2.92363E-02
15	2.68334E-02	2.68460E-02	2.68338E-02

TABLE 2-6 (Continued)

16	2.43505E-02	2.43611E-02	2.43509E-02
17	2.18137E-02	2.18240E-02	2.18140E-02
18	1.92720E-02	1.92816E-02	1.92721E-02
19	1.68522E-02	1.68615E-02	1.68523E-02
20	1.47998E-02	1.47924E-02	1.47998E-02
21	0.	0.	0.
	XRR 22 THRU XRR	35 SAME AS ABOVE	

N 3

XRR	YZT 1	YZT 2	YZT 3
1	0.	0.	0.
	XRR 2 THRU XRR	20 SAME AS ABOVE	
21	2.31682E-04	2.29923E-04	2.31684E-04
22	2.56965E-04	2.55851E-04	2.56967E-04
23	3.02378E-04	3.03170E-04	3.02383E-04
24	0.	0.	0.
	XRR 25 THRU XRR	35 SAME AS ABOVE	

N 4

XRR	YZT 1	YZT 2	YZT 3
1	0.	0.	0.
	XRR 2 THRU XRR	20 SAME AS ABOVE	
21	8.32121E-03	8.31116E-03	8.32120E-03
22	7.93172E-03	7.91453E-03	7.93171E-03
23	7.83834E-03	7.82756E-03	7.83836E-03
24	0.	0.	0.
	XRR 25 THRU XRR	35 SAME AS ABOVE	

TABLE 2-6 (Continued)

ACTIVITY 4 PLUS N

N 1

XRR	YZT 1	YZT 2	YZT 3
1	6.61261E-05	6.61385E-05	6.61262E-05
2	6.58235E-05	6.58383E-05	6.58235E-05
3	6.52322E-05	6.52443E-05	6.52324E-05
4	6.43495E-05	6.43650E-05	6.43497E-05
5	6.31842E-05	6.31950E-05	6.31844E-05
6	6.17366E-05	6.17526E-05	6.17369E-05
7	6.00207E-05	6.00303E-05	6.00211E-05
8	5.80389E-05	5.80549E-05	5.80394E-05
9	5.58094E-05	5.58179E-05	5.58100E-05
10	5.33381E-05	5.33533E-05	5.33388E-05
11	5.06457E-05	5.06537E-05	5.06464E-05
12	4.77445E-05	4.77578E-05	4.77452E-05
13	4.46556E-05	4.46634E-05	4.46563E-05
14	4.14019E-05	4.14128E-05	4.14026E-05
15	3.80120E-05	3.80187E-05	3.80127E-05
16	3.45327E-05	3.45408E-05	3.45333E-05
17	3.10644E-05	3.10677E-05	3.10650E-05
18	2.78145E-05	2.78051E-05	2.78149E-05
19	2.53685E-05	2.53738E-05	2.53689E-05
20	2.53194E-05	2.51755E-05	2.53197E-05
21	2.70488E-05	2.68539E-05	2.70490E-05
22	2.97549E-05	2.96288E-05	2.97552E-05
23	3.47328E-05	3.48165E-05	3.47332E-05
24	4.67577E-05	4.68257E-05	4.67586E-05
25	5.70475E-05	5.70794E-05	5.70486E-05
26	5.70256E-05	5.70857E-05	5.70264E-05
27	5.21341E-05	5.21361E-05	5.21345E-05
28	4.48061E-05	4.48028E-05	4.48060E-05
29	3.69794E-05	3.69845E-05	3.69788E-05
30	2.94749E-05	2.94609E-05	2.94740E-05
31	2.26978E-05	2.27025E-05	2.26967E-05
32	1.67825E-05	1.67661E-05	1.67814E-05
33	1.15974E-05	1.16068E-05	1.15964E-05
34	7.12626E-06	7.11509E-06	7.12557E-06
35	2.98698E-06	2.96806E-06	2.98669E-06

N 2

XRR	YZT 1	YZT 2	YZT 3
1	0.	0.	0.

XRR 2 THRU XRR 23 SAME AS ABOVE

Astronuclear Laboratory

TABLE 2-6 (Continued)

24	1.53083E-02	1.52831E-02	1.53084E-02
25	1.55446E-02	1.55347E-02	1.55448E-02
26	1.42324E-02	1.42259E-02	1.42325E-02
27	1.23316E-02	1.23209E-02	1.23317E-02
28	1.02337E-02	1.02283E-02	1.02337E-02
29	8.24628E-03	8.24183E-03	8.24615E-03
30	6.46018E-03	6.45497E-03	6.45998E-03
31	4.91414E-03	4.91317E-03	4.91391E-03
32	3.60176E-03	3.59730E-03	3.60152E-03
33	2.47420E-03	2.47553E-03	2.47400E-03
34	1.51556E-03	1.51296E-03	1.51542E-03
35	6.36403E-04	6.31896E-04	6.36341E-04

TABLE 2-6 (Continued)

```
ENC OF PROBLEM - TAPE CESIGNATION
               FORTRAN NAME  LOGICAL NO.

                    NCR1            3
                    NSCRAT          1
                    NBSO            8
                    NFLUX1          2
                    NAFT            4
```

TABLE 2-6 (Continued)

DOT SAMPLE PROBLEM NUMBER 2, 3 GROUP,S4,P3,R-Z,FIXED SOURCE CALCULATION

A01	PROBLEM ID NO.	13	A02	0/1 = REG./ADJ.	0
A03	ORDER OF SCATTERING	3	A04	NUMBER OF ANGLES	16
IGE	0/1/2 = X-Y/R-Z/R-T	1	IZM	NO. OF MATERIAL ZONES	3
IM	NO. OF RADIAL INT.	35	JM	NO. OF AXIAL INT.	3
I04	0/1/2/3/4/5=Q/K/ALPHA/C/Z/BQ	0	EV	EIGENVALUE GUESS	0.
EVM	EIGENVALUE MODIFIER	0.	EPS	PRECISION DESIRED	1.00000E-04
B01	LEFT BOUNDARY CONDITION	1	B02	RIGHT BOUNDARY CONDITION	0
B03	TOP BOUNDARY CONDITION	3	B04	BOTTOM BOUNDARY CONDITION	3
M07	FLUX INPUT TRIGGER	1	MODE	FLUX CALCULATION MODE	1
MT	NO. OF MATERIALS	12	M01	MIXING TABLE LENGTH	12
MCR	NO. MATLS. FROM CARDS	12	MTP	NO. MATLS. FROM LIB TAPE	0
IZ	NO. RADIAL SEARCH ZONES	0	JZ	NO. AXIAL SEARCH ZONES	0
S02	0/1/2=NONE/K/ALPHA	0	S03	PARAM. EIGEN.-SEARCH	0.
IGM	NO. OF ENERGY GROUPS	3	IHT	POSITION OF SIGMA T	3
IHS	POSITION OF SIGMA GG	4	ITL	TABLE LENGTH	6
S01	NORMALIZATION FACTOR	1.00000E+00	M05	0/N=NO/N ACT. BY ZONE	6
M06	DISTR. SOURCE INPUT TRIGGER	3	S04	INITIAL INNER ITER. MAX.	100
D05	OUTER ITER. MAX.	1	G07	INNER ITER. MAX.	100
G05	NEUTRON BALANCE EPS.	0.	G06	POINTWISE FLUX EPS.	2.00000E-04
LAL	SEARCH EPSILON	0.	LAH	1-LAMBDA MAX.-SEARCH	0.
POD	PAR. OSC. DAMP-SEARCH	0.	EPSA	NEW PAR. EPS.-SEARCH	0.
IAFT	ANG. FLUX OUTPUT TRIGGER	0	A05	NO. OF +ETA ANGLES	8
A06	NO. OF -ETA ANGLES	8	A07	NO. OF +ETA INIT. DIRECTIONS	2
A08	NO. OF -ETA INIT. DIRECTIONS	2	A09	0/1/2/3=NORMAL/SOR/SPS/CA	0
A10	0/N=ALL/N ZONES OF CONVERGENCE	0	A11	0/N=ALL/NTH INTERVAL ANG FLUXES	0
A12	NO. OF NEUTRON GROUPS	3	A13	0/1=PRINT X-SEC/DO NOT	0
A14	UPSCATTER EPSILON	1.00000E-04	A15	ENTER ZERO	0
IXBS	0/1/2/3=NC/TOP/RIGHT/BOTH-TAPE	0	IMOLD	NO. OLD RADIAL INT.	0
JMOLD	NO. OLD AXIAL INT.	0	JMLEV	AXIAL ROW FOR BNDRY SOURCE	0
IDIR	0/1=UP/DOWN DIRECTION	0	NA	STARTING INTVL,BNDRY SOURCE	0
NC	FINAL INTVL,BNDRY SOURCE	0	ISIZE	AVAILABLE CORE DATA STORAGE	30000

6208 LOCATIONS WILL BE USED FOR THIS PROBLEM

TABLE 2-6 (Continued)

```
 14* ARRAY  216 ENTRIES READ
   T
   3* ARRAY  105 ENTRIES READ
   T
   3* ARRAY  105 ENTRIES READ
   T
   3* ARRAY  105 ENTRIES READ
   T
  17* ARRAY    3 ENTRIES READ
   T
  17* ARRAY   35 ENTRIES READ
   T
  17* ARRAY    3 ENTRIES READ
   T
NON-STANDARD INPUT FORMAT USED
   7U ARRAY   32 ENTRIES READ
   T
NON-STANDARD INPUT FORMAT USED
   6U ARRAY   16 ENTRIES READ
   T
   1* ARRAY    3 ENTRIES READ
   4* ARRAY   36 ENTRIES READ
   5* ARRAY    3 ENTRIES READ
```

TABLE 2-6 (Continued)

```
 2* ARRAY    4 ENTRIES READ
 8$ ARRAY  105 ENTRIES READ
 9$ ARRAY    3 ENTRIES READ
10$ ARRAY   12 ENTRIES READ
11$ ARRAY   12 ENTRIES READ
12* ARRAY   12 ENTRIES READ
19$ ARRAY    6 ENTRIES READ
20$ ARRAY    6 ENTRIES READ
  T
```

TABLE 2-6 (Continued)

```
                    REGION DESCRIPTION BY INTERVAL
 XRR
Y
Z
T
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 3 3 3 3 3 3 3 3 3 3 3 3
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 3 3 3 3 3 3 3 3 3 3 3 3
 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 3 3 3 3 3 3 3 3 3 3 3 3
```

MATERIAL DESCRIPTION BY INTERVAL

```
 XRR
Y
Z
T
 1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  5  5  5  9  9  9  9  9  9  9  9  9  9  9  9
 1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  5  5  5  9  9  9  9  9  9  9  9  9  9  9  9
 1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  5  5  5  9  9  9  9  9  9  9  9  9  9  9  9
```

TABLE 2-6 (Continued)

I	WEIGHT	ETA	MU	MU * WT	ETA * WT	M3
1	0.	-0.86889028E+00	-0.49500473E+00	0.	0.	0.
2	0.83333333E-01	-0.86889028E+00	-0.35002120E+00	-0.29168433E-01	-0.72407523E-01	0.35002120E+00
3	0.83333333E-01	-0.86889028E+00	0.35002120E+00	0.29168433E-01	-0.72407523E-01	0.35002120E+00
4	0.	-0.35002120E+00	-0.93674178E+00	0.	0.	0.
5	0.83333333E-01	-0.35002120E+00	-0.86889028E+00	-0.72407523E-01	-0.29168433E-01	0.86889028E+00
6	0.83333333E-01	-0.35002120E+00	-0.35002120E+00	-0.29168433E-01	-0.29168433E-01	0.20878018E+01
7	0.83333333E-01	-0.35002120E+00	0.35002120E+00	0.29168433E-01	-0.29168433E-01	0.20878018E+01
8	0.83333333E-01	-0.35002120E+00	0.86889028E+00	0.72407523E-01	-0.29168433E-01	0.86889028E+00
9	0.	0.86889028E+00	-0.49500473E+00	0.	0.	0.
10	0.83333333E-01	0.86889028E+00	-0.35002120E+00	-0.29168433E-01	0.72407523E-01	0.35002120E+00
11	0.83333333E-01	0.86889028E+00	0.35002120E+00	0.29168433E-01	0.72407523E-01	0.35002120E+00
12	0.	0.35002120E+00	-0.93674178E+00	0.	0.	0.
13	0.83333333E-01	0.35002120E+00	-0.86889028E+00	-0.72407523E-01	0.29168433E-01	0.86889028E+00
14	0.83333333E-01	0.35002120E+00	-0.35002120E+00	-0.29168433E-01	0.29168433E-01	0.20878018E+01
15	0.83333333E-01	0.35002120E+00	0.35002120E+00	0.29168433E-01	0.29168433E-01	0.20878018E+01
16	0.83333333E-01	0.35002120E+00	0.86889028E+00	0.72407523E-01	0.29168433E-01	0.86889028E+00

DISCRETE VALUES OF PLM(THETA)*COS(M*PSI)

ANGL	PLMC 1	PLMC 2	PLMC 3	PLMC 4	PLMC 5	PLMC 6	PLMC 7	PLMC 8
1	-4.95005E-01	-8.68890E-01	-1.32455E-01	7.44963E-01	6.53823E-01	4.39280E-01	-1.19798E-01	-7.23694E-01
2	-3.50021E-01	-8.68890E-01	-3.16228E-01	5.26769E-01	5.47723E-01	4.17825E-01	2.06143E-01	-4.28687E-01
3	3.50021E-01	-8.68890E-01	-3.16228E-01	-5.26769E-01	5.47723E-01	-4.17825E-01	2.06143E-01	4.28687E-01
4	-9.36742E-01	-3.50021E-01	8.16228E-01	5.67904E-01	1.06101E-01	-6.49830E-01	-7.26072E-01	-2.22241E-01
5	-8.68890E-01	-3.50021E-01	6.32455E-01	5.26769E-01	0.	-3.36631E-01	-5.94771E-01	0.
6	-3.50021E-01	-3.50021E-01	-3.16228E-01	2.12202E-01	-5.47722E-01	4.17825E-01	8.30421E-02	4.28687E-01
7	3.50021E-01	-3.50021E-01	-3.16228E-01	-2.12202E-01	-5.47722E-01	-4.17825E-01	8.30421E-02	-4.28687E-01
8	8.68890E-01	-3.50021E-01	6.32455E-01	-5.26769E-01	0.	3.36631E-01	-5.94771E-01	0.
9	-4.95005E-01	8.68890E-01	-1.32455E-01	-7.44963E-01	6.53823E-01	4.39280E-01	1.19798E-01	-7.23694E-01
10	-3.50021E-01	8.68890E-01	-3.16228E-01	-5.26769E-01	5.47723E-01	4.17825E-01	-2.06143E-01	-4.28687E-01
11	3.50021E-01	8.68890E-01	-3.16228E-01	5.26769E-01	5.47723E-01	-4.17825E-01	-2.06143E-01	4.28687E-01
12	-9.36742E-01	3.50021E-01	8.16228E-01	-5.67904E-01	1.06101E-01	-6.49830E-01	7.26072E-01	-2.22241E-01
13	-8.68890E-01	3.50021E-01	6.32455E-01	-5.26769E-01	0.	-3.36631E-01	5.94771E-01	0.
14	-3.50021E-01	3.50021E-01	-3.16228E-01	-2.12202E-01	-5.47723E-01	4.17825E-01	-8.30421E-02	4.28687E-01
15	3.50021E-01	3.50021E-01	-3.16228E-01	2.12202E-01	-5.47723E-01	-4.17825E-01	-8.30421E-02	-4.28687E-01
16	8.68890E-01	3.50021E-01	6.32455E-01	5.26769E-01	0.	3.36631E-01	5.94771E-01	0.

ANGL	PLMC 9
1	-5.18603E-01
2	-2.66130E-01
3	-2.66130E-01
4	-3.39018E-02
5	6.78036E-02
6	5.92835E-01
7	5.92835E-01
8	6.78036E-02
9	-5.18603E-01
10	2.66130E-01
11	2.66130E-01
12	3.39018E-02
13	-6.78036E-02
14	-5.92835E-01
15	-5.92835E-01
16	-6.78036E-02

CROSS-SECTION EDIT

GROUP 1 CROSS-SECTIONS

POS.	MAT. 1	MAT. 2	MAT. 3	MAT. 4	MAT. 5	MAT. 6	MAT. 7	MAT. 8
1	1.37920E-03	0.	0.	0.	4.52270E-04	0.	0.	0.
2	2.46450E-03	0.	0.	0.	0.	0.	0.	0.
3	4.92230E-01	0.	0.	0.	3.20870E-01	0.	0.	0.
4	4.41070E-01	6.50010E-01	5.39760E-01	1.72460E-01	3.20150E-01	1.89710E-01	3.17900E-01	1.36200E-01
5	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.

POS.	MAT. 9	MAT. 10	MAT. 11	MAT. 12
1	1.82740E-04	0.	0.	0.
2	0.	0.	0.	0.
3	6.09500E-01	0.	0.	0.
4	5.23060E-01	8.97530E-01	6.72620E-01	3.19100E-01
5	0.	0.	0.	0.
6	0.	0.	0.	0.

GROUP 2 CROSS-SECTIONS

POS.	MAT. 1	MAT. 2	MAT. 3	MAT. 4	MAT. 5	MAT. 6	MAT. 7	MAT. 8
1	1.97530E-02	0.	0.	0.	6.68390E-03	0.	0.	0.
2	2.68160E-02	0.	0.	0.	0.	0.	0.	0.
3	1.26480E+00	0.	0.	0.	7.85530E-01	0.	0.	0.
4	1.19460E+00	1.84070E+00	1.21180E+00	9.88330E-02	7.77930E-01	8.91850E-02	4.85950E-02	2.77480E-02
5	4.97790E-02	3.41950E-02	-1.53340E-02	-8.29680E-02	2.67900E-04	-1.07300E-04	-1.33800E-06	1.73420E-06
6	0.	0.	0.	0.	0.	0.	0.	0.

POS.	MAT. 9	MAT. 10	MAT. 11	MAT. 12
1	7.69820E-04	0.	0.	0.
2	0.	0.	0.	0.
3	1.46540E+00	0.	0.	0.
4	1.37090E+00	2.59660E+00	1.72160E+00	1.58000E-01
5	8.62510E-02	5.50360E-02	-2.76100E-02	-4.39360E-02
6	0.	0.	0.	0.

GROUP 3 CROSS-SECTIONS

POS.	MAT. 1	MAT. 2	MAT. 3	MAT. 4	MAT. 5	MAT. 6	MAT. 7	MAT. 8
1	1.77130E-01	0.	0.	0.	7.71680E-02	0.	0.	0.
2	3.02050E-01	0.	0.	0.	0.	0.	0.	0.
3	1.68600E+00	0.	0.	0.	9.81140E-01	0.	0.	0.
4	1.50890E+00	0.	0.	0.	9.03970E-01	0.	0.	0.
5	5.04050E-02	5.01240E-02	-4.71870E-02	-8.24670E-02	9.08100E-04	-4.83030E-04	-1.43160E-05	3.98390E-04

TABLE 2-6 (Continued)

6	1.36370E-06	4.95220E-09	-7.78200E-07	-2.10590E-08	0.	0.	0.	0.

POS.	MAT. 9	MAT. 10	MAT. 11	MAT. 12
1	8.69440E-03	0.	0.	0.
2	0.	0.	0.	0.
3	1.79370E+00	0.	0.	0.
4	1.78500E+00	0.	0.	0.
5	9.36340E-02	9.55940E-02	-4.63020E-02	-1.48920E-01
6	2.36640E-06	7.96350E-09	-1.34770E-06	-1.09180E-08

TABLE 2-6 (Continued)

DISTRIBUTED SOURCE FOR GROUP 1

XRR	YZT 1	YZT 2	YZT 3
1	1.50082E-03	1.50082E-03	1.50082E-03
2	1.49462E-03	1.49462E-03	1.49462E-03
3	1.48216E-03	1.48216E-03	1.48216E-03
4	1.46378E-03	1.46378E-03	1.46378E-03
5	1.43920E-03	1.43920E-03	1.43920E-03
6	1.40878E-03	1.40878E-03	1.40878E-03
7	1.37230E-03	1.37230E-03	1.37230E-03
8	1.33019E-03	1.33019E-03	1.33019E-03
9	1.28216E-03	1.28216E-03	1.28216E-03
10	1.22892E-03	1.22892E-03	1.22892E-03
11	1.17019E-03	1.17019E-03	1.17019E-03
12	1.10674E-03	1.10674E-03	1.10674E-03
13	1.03836E-03	1.03836E-03	1.03836E-03
14	9.66039E-04	9.66039E-04	9.66039E-04
15	8.89843E-04	8.89843E-04	8.89843E-04
16	8.11323E-04	8.11323E-04	8.11323E-04
17	7.32381E-04	7.32381E-04	7.32381E-04
18	6.58319E-04	6.58319E-04	6.58319E-04
19	6.04679E-04	6.04679E-04	6.04679E-04
20	6.07193E-04	6.07193E-04	6.07193E-04
21	0.	0.	0.

XRR 22 THRU XRR 35 SAME AS ABOVE

DISTRIBUTED SOURCE FOR GROUP 2

XRR	YZT 1	YZT 2	YZT 3
1	0.	0.	0.

XRR 2 THRU XRR 35 SAME AS ABOVE

DISTRIBUTED SOURCE FOR GROUP 3

XRR	YZT 1	YZT 2	YZT 3
1	0.	0.	0.

XRR 2 THRU XRR 35 SAME AS ABOVE

TABLE 2-6 (Continued)

	MIXTURE SUM	COMPONENT	DENSITY	RADIUS	R MIDPOINT	HEIGHT	H MIDPOINT	MAT. BY ZONE
1	1	0	1.00000E+00	0	4.56825E-01	0	1.65000E-01	-1
2	2	0	1.00000E+00	9.13650E-01	1.37047E+00	3.30000E-01	5.00000E-01	-5
3	3	0	1.C0000E+00	1.82730E+00	2.28412E+00	6.70000E-01	8.35000E-01	-9
4	4	0	1.C0000E+00	2.74095E+00	3.19777E+00	1.00000E+00		
5	5	0	1.00000E+00	3.65460E+00	4.11142E+00			
6	6	0	1.C0000E+00	4.56825E+00	5.02507E+00			
7	7	0	1.C0000E+00	5.48190E+00	5.93872E+00			
8	8	0	1.00000E+00	6.39555E+00	6.85237E+00			
9	9	0	1.00000E+00	7.30920E+00	7.76602E+00			
10	10	0	1.C0000E+00	8.22285E+00	8.67967E+00			
11	11	0	1.C0000E+00	9.13650E+00	9.59332E+00			
12	12	0	1.C000CE+00	1.00501E+01	1.05070E+01			
13				1.09638E+01	1.14206E+01			
14				1.18774E+01	1.23343E+01			
15				1.27911E+01	1.32479E+01			
16				1.37047E+01	1.41616E+01			
17				1.46184E+01	1.50752E+01			
18				1.55320E+01	1.59889E+01			
19				1.64457E+01	1.69025E+01			
20				1.73593E+01	1.78162E+01			
21				1.82730E+01	1.84997E+01			
22				1.87263E+01	1.89530E+01			
23				1.91797E+01	1.94063E+01			
24				1.96330E+01	2.01542E+01			
25				2.06755E+01	2.11967E+01			
26				2.17180E+01	2.22392E+01			
27				2.27605E+01	2.32817E+01			
28				2.38030E+01	2.43243E+01			
29				2.48455E+01	2.53667E+01			
30				2.58880E+01	2.64092E+01			
31				2.69305E+01	2.74517E+01			
32				2.79730E+01	2.84942E+01			
33				2.90155E+01	2.95367E+01			
34				3.00580E+01	3.05792E+01			
35				3.11005E+01	3.16217E+01			
36				3.21430E+01				

	FIS. SPECTRUM	VELOCITY
1	0	1.000C0E+00
2	0	1.CCCCCE+CO
3	0	1.000CCE+C0

TABLE 2-6 (Continued)

```
FLUX  2 LC  0 II    0 NB  0.          USF 0.             EQ  0.           EV . 0.              LA . 0.
  GROUP     1 INNER ITERATIONS =  76 FLUX ERROR MAX =  1.87277E-04   AT ( 35,  2)
  GROUP     2 INNER ITERATIONS =  64 FLUX ERROR MAX =  1.94146E-04   AT ( 35,  3)
  GROUP     3 INNER ITERATIONS = 100 FLUX ERROR MAX =  5.04288E-04   AT ( 35,  3)
```

TABLE 2-6 (Continued)

BALANCE TABLE SUMMARY

GROUP	FIXED SO	FISSION SO	IN-SCATTER	SELF-SCATTER	HZ-LEAKAGE	ABSORPTIONS	OUT-SCATTER	RT-LEAKAG
1	1.00000E+00	0.	0.	8.66878E+00	3.32122E-04	2.50593E-02	9.74609E-01	3.32122E-0
2	0.	0.	9.74571E-01	1.67039E+01	6.82742E-04	2.43269E-01	7.30620E-01	6.82742E-0
3	0.	0.	7.30010E-01	1.77797E+01	1.16637E-02	7.18442E-01	-6.65197E-05	1.16637E-0
4	1.00000E+00	0.	1.70458E+00	4.31524E+01	1.26786E-02	9.86770E-01	1.70516E+00	1.26786E-0

GROUP	VT-LEAKAGE	TOP-LEAKAGE	NET-LEAKAGE	BALANCE
1	-5.79142E-07	-5.79142E-07	3.31543E-04	1.00000E+00
2	-1.36107E-06	-1.36107E-06	6.81381E-04	1.00000E+00
3	-2.92872E-05	-2.92872E-05	1.16345E-02	1.00000E+00
4	-3.12274E-05	-3.12274E-05	1.26474E-02	1.00000E+00

FLUX 1 LC 1 II 240 NB 9.999999E-01 LSF 0. EQ 0. EV 0. LA 1.00000000E+00

TABLE 2-6 (Continued)

I	RADIUS	R MIDPOINT	HEIGHT	H MIDPOINT
1	0.	4.5682500E-01	0.	1.6500000E-01
2	9.1365000E-01	1.3704750E+00	3.3000000E-01	5.0000000E-01
3	1.8273000E+00	2.2841250E+00	6.7000000E-01	8.3500000E-01
4	2.7409500E+00		1.0000000E+00	
		3.1977750E+00		
5	3.6546000E+00	4.1114250E+00		
6	4.5682500E+00	5.0250750E+00		
7	5.4819000E+00	5.9387250E+00		
8	6.3955500E+00	6.8523750E+00		
9	7.3092000E+00	7.7660250E+00		
10	8.2228500E+00	8.6796750E+00		
11	9.1365000E+00	9.5933250E+00		
12	1.0050150E+01	1.0506975E+01		
13	1.0963800E+01	1.1420625E+01		
14	1.1877450E+01	1.2334275E+01		
15	1.2791100E+01	1.3247925E+01		
16	1.3704750E+01	1.4161575E+01		
17	1.4618400E+01	1.5075225E+01		
18	1.5532050E+01	1.5988875E+01		
19	1.6445700E+01	1.6902525E+01		
20	1.7359350E+01	1.7816175E+01		
21	1.8273000E+01	1.8499667E+01		
22	1.8726333E+01	1.8953000E+01		
23	1.9179667E+01	1.9406333E+01		
24	1.9633000E+01	2.0154250E+01		
25	2.0675500E+01	2.1196750E+01		
26	2.1718000E+01	2.2239250E+01		
27	2.2760500E+01	2.3281750E+01		
28	2.3803000E+01	2.4324250E+01		
29	2.4845500E+01	2.5366750E+01		
30	2.5888000E+01	2.6409250E+01		
31	2.6930500E+01	2.7451750E+01		
32	2.7973000E+01	2.8494250E+01		
33	2.9015500E+01	2.9536750E+01		
34	3.0058000E+01	3.0579250E+01		
35	3.1100500E+01	3.1621750E+01		
36	3.2143000E+01			

TABLE 2-6 (Continued)

FLUX FOR GROUP 1

XRR	YZT= 1	YZT= 2	YZT= 3
1	2.7410E-02	2.7430E-02	2.7410E-02
2	2.7290E-02	2.7311E-02	2.7290E-02
3	2.7056E-02	2.7077E-02	2.7056E-02
4	2.6709E-02	2.6730E-02	2.6709E-02
5	2.6249E-02	2.6270E-02	2.6249E-02
6	2.5677E-02	2.5697E-02	2.5677E-02
7	2.4996E-02	2.5016E-02	2.4996E-02
8	2.4209E-02	2.4228E-02	2.4209E-02
9	2.3318E-02	2.3337E-02	2.3318E-02
10	2.2329E-02	2.2347E-02	2.2329E-02
11	2.1245E-02	2.1263E-02	2.1245E-02
12	2.0073E-02	2.0089E-02	2.0073E-02
13	1.8819E-02	1.8835E-02	1.8819E-02
14	1.7491E-02	1.7506E-02	1.7491E-02
15	1.6097E-02	1.6112E-02	1.6097E-02
16	1.4646E-02	1.4658E-02	1.4646E-02
17	1.3143E-02	1.3156E-02	1.3143E-02
18	1.1586E-02	1.1603E-02	1.1586E-02
19	9.9804E-03	9.9996E-03	9.9804E-03
20	8.1814E-03	8.2160E-03	8.1814E-03
21	6.6749E-03	6.6992E-03	6.6749E-03
22	5.6503E-03	5.6457E-03	5.6503E-03
23	4.6475E-03	4.6075E-03	4.6475E-03
24	3.2240E-03	3.1744E-03	3.2240E-03
25	1.8319E-03	1.8029E-03	1.8319E-03
26	1.0729E-03	1.0510E-03	1.0729E-03
27	6.1663E-04	6.0593E-04	6.1663E-04
28	3.5676E-04	3.5172E-04	3.5676E-04
29	2.0798E-04	2.0303E-04	2.0798E-04
30	1.1968E-04	1.1845E-04	1.1968E-04
31	6.9643E-05	6.7919E-05	6.9643E-05
32	3.9939E-05	3.9526E-05	3.9939E-05
33	2.2630E-05	2.2031E-05	2.2630E-05
34	1.2045E-05	1.1994E-05	1.2044E-05
35	5.3874E-06	5.0424E-06	5.3873E-06

TABLE 2-6 (Continued)

FLUX FOR GROUP 2

XRR	YZT= 1	YZT= 2	YZT= 3
1	1.8680E-02	1.8685E-02	1.8680E-02
2	1.8597E-02	1.8603E-02	1.8597E-02
3	1.8436E-02	1.8442E-02	1.8436E-02
4	1.8197E-02	1.8202E-02	1.8197E-02
5	1.7879E-02	1.7885E-02	1.7879E-02
6	1.7485E-02	1.7490E-02	1.7485E-02
7	1.7015E-02	1.7021E-02	1.7015E-02
8	1.6473E-02	1.6479E-02	1.6473E-02
9	1.5861E-02	1.5866E-02	1.5861E-02
10	1.5181E-02	1.5186E-02	1.5181E-02
11	1.4437E-02	1.4442E-02	1.4437E-02
12	1.3633E-02	1.3638E-02	1.3633E-02
13	1.2773E-02	1.2778E-02	1.2773E-02
14	1.1863E-02	1.1867E-02	1.1863E-02
15	1.0906E-02	1.0911E-02	1.0906E-02
16	9.9095E-03	9.9131E-03	9.9096E-03
17	8.8761E-03	8.8798E-03	8.8762E-03
18	7.8126E-03	7.8165E-03	7.8126E-03
19	6.7286E-03	6.7288E-03	6.7286E-03
20	5.6241E-03	5.6290E-03	5.6240E-03
21	4.7691E-03	4.7761E-03	4.7691E-03
22	4.2035E-03	4.2013E-03	4.2035E-03
23	3.6864E-03	3.6743E-03	3.6863E-03
24	2.9822E-03	2.9736E-03	2.9822E-03
25	2.1295E-03	2.1290E-03	2.1295E-03
26	1.4471E-03	1.4421E-03	1.4471E-03
27	9.5470E-04	9.5071E-04	9.5469E-04
28	6.1315E-04	6.1076E-04	6.1314E-04
29	3.8865E-04	3.8655E-04	3.8864E-04
30	2.4241E-04	2.4113E-04	2.4240E-04
31	1.4935E-04	1.4861E-04	1.4935E-04
32	9.0829E-05	9.0180E-05	9.0827E-05
33	5.3461E-05	5.3252E-05	5.3459E-05
34	2.9965E-05	2.9750E-05	2.9964E-05
35	1.3303E-05	1.2986E-05	1.3303E-05

TABLE 2-6 (Continued)

FLUX FOR GROUP 3

XRR	YZT= 1	YZT= 2	YZT= 3
1	5.2885E-03	5.2892E-03	5.2894E-03
2	5.2652E-03	5.2661E-03	5.2661E-03
3	5.2197E-03	5.2202E-03	5.2206E-03
4	5.1515E-03	5.1524E-03	5.1523E-03
5	5.0614E-03	5.0619E-03	5.0623E-03
6	4.9493E-03	4.9504E-03	4.9501E-03
7	4.8163E-03	4.8166E-03	4.8171E-03
8	4.6622E-03	4.6633E-03	4.6630E-03
9	4.4886E-03	4.4888E-03	4.4893E-03
10	4.2955E-03	4.2965E-03	4.2962E-03
11	4.0847E-03	4.0849E-03	4.0854E-03
12	3.8568E-03	3.8577E-03	3.8574E-03
13	3.6134E-03	3.6137E-03	3.6140E-03
14	3.3563E-03	3.3570E-03	3.3569E-03
15	3.0879E-03	3.0881E-03	3.0884E-03
16	2.8124E-03	2.8129E-03	2.8129E-03
17	2.5408E-03	2.5407E-03	2.5412E-03
18	2.2962E-03	2.2945E-03	2.2965E-03
19	2.1454E-03	2.1457E-03	2.1457E-03
20	2.2760E-03	2.2582E-03	2.2762E-03
21	2.5833E-03	2.5596E-03	2.5835E-03
22	2.9682E-03	2.9540E-03	2.9683E-03
23	3.6122E-03	3.6238E-03	3.6123E-03
24	5.0950E-03	5.1048E-03	5.0953E-03
25	6.3790E-03	6.3834E-03	6.3792E-03
26	6.4302E-03	6.4380E-03	6.4301E-03
27	5.8922E-03	5.8928E-03	5.8918E-03
28	5.0587E-03	5.0591E-03	5.0581E-03
29	4.1630E-03	4.1636E-03	4.1623E-03
30	3.3056E-03	3.3039E-03	3.3050E-03
31	2.5353E-03	2.5358E-03	2.5347E-03
32	1.8675E-03	1.8656E-03	1.8671E-03
33	1.2865E-03	1.2875E-03	1.2862E-03
34	7.8866E-04	7.8738E-04	7.8846E-04
35	3.3000E-04	3.2792E-04	3.2992E-04

TABLE 2-6 (Continued)

FISSION EDIT

XRR	YZT= 1	YZT= 2	YZT= 3
1	2.1659E-03	2.1663E-03	2.1661E-03
2	2.1563E-03	2.1568E-03	2.1566E-03
3	2.1377E-03	2.1381E-03	2.1379E-03
4	2.1098E-03	2.1103E-03	2.1100E-03
5	2.0729E-03	2.0733E-03	2.0732E-03
6	2.0271E-03	2.0276E-03	2.0273E-03
7	1.9726E-03	1.9729E-03	1.9729E-03
8	1.9096E-03	1.9101E-03	1.9099E-03
9	1.8386E-03	1.8388E-03	1.8388E-03
10	1.7596E-03	1.7601E-03	1.7598E-03
11	1.6733E-03	1.6735E-03	1.6735E-03
12	1.5800E-03	1.5804E-03	1.5802E-03
13	1.4803E-03	1.4806E-03	1.4805E-03
14	1.3750E-03	1.3754E-03	1.3752E-03
15	1.2648E-03	1.2650E-03	1.2650E-03
16	1.1513E-03	1.1516E-03	1.1515E-03
17	1.0379E-03	1.0380E-03	1.0380E-03
18	9.3162E-04	9.3127E-04	9.3173E-04
19	8.5305E-04	8.5319E-04	8.5314E-04
20	8.5844E-04	8.5330E-04	8.5851E-04
21	0.	0.	0.
22	0.	0.	0.
23	0.	0.	0.
24	0.	0.	0.
25	0.	0.	0.
26	0.	0.	0.
27	0.	0.	0.
28	0.	0.	0.
29	0.	0.	0.
30	0.	0.	0.
31	0.	0.	0.
32	0.	0.	0.
33	0.	0.	0.
34	0.	0.	0.
35	0.	0.	0.

TABLE 2-6 (Continued)

ACTIVITY	MATERIAL	POSITION
1	1	1
2	1	3
3	5	1
4	5	3
5	9	1
6	9	3

TABLE 2-6 (Continued)

ACTIVITY   O PLUS N

N   1

XRR	YZT 1	YZT 2	YZT 3
1	1.34354E-03	1.34379E-03	1.34370E-03
2	1.33762E-03	1.33792E-03	1.33777E-03
3	1.32605E-03	1.32630E-03	1.32620E-03
4	1.30875E-03	1.30907E-03	1.30891E-03
5	1.28590E-03	1.28612E-03	1.28605E-03
6	1.25746E-03	1.25779E-03	1.25761E-03
7	1.22369E-03	1.22388E-03	1.22383E-03
8	1.18459E-03	1.18492E-03	1.18473E-03
9	1.14051E-03	1.14069E-03	1.14065E-03
10	1.09152E-03	1.09183E-03	1.09165E-03
11	1.03799E-03	1.03816E-03	1.03811E-03
12	9.80128E-04	9.80407E-04	9.80244E-04
13	9.18315E-04	9.18478E-04	9.18423E-04
14	8.52958E-04	8.53190E-04	8.53058E-04
15	7.84590E-04	7.84732E-04	7.84682E-04
16	7.14102E-04	7.14281E-04	7.14186E-04
17	6.43507E-04	6.43580E-04	6.43582E-04
18	5.77024E-04	5.76834E-04	5.77089E-04
19	5.26688E-04	5.26772E-04	5.26744E-04
20	5.25523E-04	5.22525E-04	5.25565E-04
21	0.	0.	0.

XRR 22 THRU XRR 35 SAME AS ABOVE

N   2

XRR	YZT 1	YZT 2	YZT 3
1	4.60345E-02	4.60527E-02	4.60360E-02
2	4.58317E-02	4.58511E-02	4.58332E-02
3	4.54365E-02	4.54552E-02	4.54380E-02
4	4.48475E-02	4.48667E-02	4.48490E-02
5	4.40675E-02	4.40857E-02	4.40689E-02
6	4.30984E-02	4.31173E-02	4.30998E-02
7	4.19453E-02	4.19629E-02	4.19467E-02
8	4.06121E-02	4.06304E-02	4.06135E-02
9	3.91061E-02	3.91227E-02	3.91074E-02
10	3.74335E-02	3.74507E-02	3.74347E-02
11	3.56037E-02	3.56193E-02	3.56049E-02
12	3.36259E-02	3.36417E-02	3.36270E-02
13	3.15114E-02	3.15257E-02	3.15124E-02
14	2.92728E-02	2.92866E-02	2.92738E-02
15	2.69239E-02	2.69370E-02	2.69248E-02

16	2.44847E-02	2.44959E-02	2.44855E-02
17	2.19795E-02	2.19905E-02	2.19802E-02
18	1.94557E-02	1.94664E-02	1.94563E-02
19	1.70401E-02	1.70503E-02	1.70406E-02
20	1.49778E-02	1.49712E-02	1.49781E-02
21	0.	0.	0.
	XRR 22 THRU	XRR	35 SAME AS ABOVE

N 3

XRR	YZT 1	YZT 2	YZT 3
1	0.	0.	0.
	XRR 2 THRU	XRR	20 SAME AS ABOVE
21	2.34245E-04	2.32474E-04	2.34257E-04
22	2.59701E-04	2.58588E-04	2.59711E-04
23	3.05484E-04	3.06284E-04	3.05498E-04
24	0.	0.	0.
	XRR 25 THRU	XRR	35 SAME AS ABOVE

N 4

XRR	YZT 1	YZT 2	YZT 3
1	0.	0.	0.
	XRR 2 THRU	XRR	20 SAME AS ABOVE
21	8.42262E-03	8.41272E-03	8.42276E-03
22	8.02717E-03	8.01005E-03	8.02729E-03
23	7.93101E-03	7.92017E-03	7.93117E-03
24	0.	0.	0.
	XRR 25 THRU	XRR	35 SAME AS ABOVE

TABLE 2-6 (Continued)

ACTIVITY 4 PLUS N

N 1

XRR	YZT 1	YZT 2	YZT 3
1	0.	0.	0.
XRR 2 THRU XRR 23 SAME AS ABOVE			
24	4.71832E-05	4.72527E-05	4.71854E-05
25	5.74359E-05	5.74685E-05	5.74372E-05
26	5.72167E-05	5.72770E-05	5.72155E-05
27	5.20766E-05	5.20770E-05	5.20732E-05
28	4.45198E-05	4.45207E-05	4.45148E-05
29	3.65320E-05	3.65350E-05	3.65263E-05
30	2.89489E-05	2.89331E-05	2.89434E-05
31	2.21706E-05	2.21737E-05	2.21657E-05
32	1.63143E-05	1.62969E-05	1.63104E-05
33	1.12308E-05	1.12391E-05	1.12279E-05
34	6.88223E-06	6.87089E-06	6.88044E-06
35	2.88038E-06	2.86198E-06	2.87966E-06

N 2

XRR	YZT 1	YZT 2	YZT 3
1	0.	0.	0.
XRR 2 THRU XRR 23 SAME AS ABOVE			
24	1.54742E-02	1.54488E-02	1.54746E-02
25	1.56792E-02	1.56692E-02	1.56794E-02
26	1.43084E-02	1.43017E-02	1.43081E-02
27	1.23437E-02	1.23324E-02	1.23429E-02
28	1.01898E-02	1.01840E-02	1.01887E-02
29	8.16346E-03	8.15852E-03	8.16228E-03
30	6.35748E-03	6.35183E-03	6.35632E-03
31	4.80887E-03	4.80756E-03	4.80785E-03
32	3.50724E-03	3.50257E-03	3.50643E-03
33	2.39975E-03	2.40086E-03	2.39916E-03
34	1.46588E-03	1.46323E-03	1.46551E-03
35	6.14700E-04	6.10290E-04	6.14551E-04

```
END OF PROBLEM - TAPE DESIGNATION
                FORTRAN NAME  LOGICAL NO.

                     N[illegible]RI           3
                     NSCRAT         2
                     N[illegible]SO           8
                     NFLUXI         1
                     NAFT           4
```

(c) ETA (6*), the direction cosine of angle M with respect to the Y, Z, or THETA axis.

(d) MU(6*), the direction cosine of angle M with respect to the X or R axis.

(e) MU*WT, the product of d and b.

(f) ETA*WT, the product of c and b.

(g) M3, a term used in the geometric angular redistribution.

(h) M4, the ETA mates for top and bottom boundary reflection.

(i) M6, the MU mates for left and right boundary reflection.

(8) If A03 > 0, the constants used by the moment operators in the anisotropic inscatter integral are printed.

(9) The cross sections are printed by group, material, and position (14*). A two-dimensional table of material and position is printed by group. The material numbers correspond to those used in the mixing table, materials by zone, material picture plot, and activity calculations.

(10) IF I04 = 0, the fixed distributed source is printed as a two-dimensional array of radial intervals by number of axial intervals for each group (17*). The source values printed out have been normalized such that the total integrated fixed source equals the normalization factor. If no normalization is desired (S01 = 0.0) then the fixed distributed source is not printed out.

(11) If I04 = 5, the boundary source is printed (18*). If a source is present at both the right and top boundaries, the right boundary source and then the top boundary source is printed for each group. The correspondence between the angle numbers and the S_n constants is given in the Section 2.3.3 on boundary source input.

(12) The important one-dimensional arrays are printed. These include the following:

(a) The mixing table mixture numbers. (10$)

(b) The mixing table component numbers. (11$)

(c) The mixing table densities. (12*)

(d) The radii of the radial interval boundaries. (4*)

(e) The radii of the interval midpoints.

(f) The height of the axial interval boundaries. (2*)

(g) The height of the interval midpoints.

(h) The materials by zone. (9$)

(i) The fission spectrum. (1*)

(j) The velocities. (5*)

(k) If I04 = 4, the radial search zone numbers. (21$)

(l) If I04 = 4, the radial zone modifiers. (22*)

(m) If I04 = 4, the axial search zone numbers. (23$)

(n) If I04 = 4, the axial zone modifiers. (24*)

(o) If B02 = 5, the right boundary albedos. (25*)

(p) If B03 = 5, the top boundary albedos. (26*)

(q) If B04 = 5, the bottom boundary albedos. (27*)

(r) If A09 = 2, the dominance ratio dependent scale cycle by energy group.

(s) If A10 $\neq$ 0, the zones of convergence. (28$)

Output from Calculations

The remainder of the printed output contains quantities calculated by DOT-IIW. The printout is arranged in the following order:

(1) The monitor and group line prints. The monitor line is printed at the end of each outer iteration and contains the following information

(a) The logical number of the scalar flux tape, NFLUX1.

(b) The outer iteration number, LC.

(c) The number of inner iterations in the last outer iteration, II.

(d) The neutron balance, NB, or the ratio of source rate to the loss rate.

(e) The ratio of upscatter source between two successive outer iterations.

(f) If a search, the slope, dEV/dLA.

(g) The eigenvalue, EV.

(h) The ratio of sources, LAMBDA.

The group line contains the group number, number of inner iterations for that group in the indicated outer iteration, and the maximum pointwise flux error and the location where the maximum pointwise flux error occurred in the material map. The group line is printed for each group and each outer iteration if G06 $\neq$ 0.

(2) The angular fluxes. If IAFT = 2 or 3, the angular fluxes are printed by group, space point, and angle. The angular flux has units of average neutron (or photon) speed per unit volume per unit angular weight, or 4 π times the average neutron (or photon) speed per unit volume per unit solid angle (steradian). The fluxes are printed in two-dimensional arrays of radial interval by angle. Each array is preceded by a title giving the group and axial interval. A FLAG = -1.0 in the title means that the angle numbers correspond to the same angle numbers in the S_n constants. A FLAG = +1.0 in the title means that the angle number, N, corresponds to angle N+MM/2 in the S_n constants where MM is the total number of angles. When the angular fluxes are printed, the group line for each group appears at the end of each set of angular fluxes for that group.

(3) Balance table. DOT-IIW prints a system balance table for all problems. The following items are printed as seperate columns:

(a) FIXED S0, the distributed or boundary source.

(b) FISSION S0, the fission source.

(c) IN-SCATTER, the rate of scattering into the group.

(d) SELF-SCATTER, the within group scattering.

(e) HZ-LEAKAGE, the right boundary leakage minus the left boundary leakage.

(f) ABSORPTIONS, the absorption rate.

(g) OUT-SCATTER, the rate of scattering from the group.

(h) RT-LEAKAGE, the right boundary leakage.

(i) VT-LEAKAGE, the top boundary leakage minus the bottom boundary leakage.

(j) TOP-LEAKAGE, the top boundary leakage.

(k) NET-LEAKAGE, the horizontal plus vertical leakage.

(l) BALANCE, source rate divided by loss rate.

(4) The final monitor line.

(5) The final values (in the case of search calculations for the radial and axial interval boundaries and interval midpoints).

(6) The scalar fluxes are printed by space point and by energy group.

(7) Fission edit. The fission neutron source rate per unit volume is printed by space point.

(8) Flux moments. If A03≠0 and IAFT = 1, 2, or 3, the moments of the flux are printed by group, moment number, and space point. A flux moment is the product of angular flux, moment operator, and angle weight summed over angle. Usually the first moment is the radial current and the second is the axial current.

(9) Activities. The specified activities are printed next in the output. An activity is a sum over groups of the product of the scalar flux and the cross section in the material and position indicated in the 19$ and 20$ arrays. The activities are printed by activity number and space point and are preceded by a table giving the correspondence between activity number and the specified material number and cross section table position.

(10) Tape designation. Because tapes are manipulated in the DOT-IIW code to minimize computer time, a convenient list of final tape assignments is printed as follows:

(a) NCR1 contains the processed cross sections and may be used in subsequent problems merely by (1) specifying no cross sections from cards or tape; and (2) by mounting this tape on the appropriate drive.

(b) NSCRAT is a scratch tape used for intermediate calculations.

(c) NBSO is a tape containing the normalized boundary source, if specified.

(d) NFLUX1 is a tape which contains the converged scalar fluxes and surface angular fluxes as well as the higher flux moments.

(e) NAFT contains the angular fluxes and other selected parameters. NOTE: The scalar flux is always written on Tape 11 at the end of a calculation.

2.5.2 Output Flux Tape

Almost all of the usual information desired from a calculation is contained in the printed output; however, some problems may require additional computer code analysis with the NAGS and MAP codes. These codes use the output flux tape as input data; this flux tape is written in the binary mode and contains one logical record for each group. To facilitate use of the scalar flux tape, the format is described in the following list:

(1) The first IM*JM words in the record contain the scalar flux in the order (1, 1), (2, 1), ..., (IM, 1); (1, 2), (2, 2), ..., (IM, 2); . . ., (IM, JM).

(2) The next IM*JM* (A03+A03+3))/2 words contain the flux moments. The terms are arranged by interval in the same order as the scalar fluxes for each moment operator. If A03 = 0, then a single word containing all zero bits is written.

(3) The next MM*JM words contain the outgoing angular fluxes at the left and right boundaries. The angular fluxes are arranged by angle and axial interval in the order (1, 1), ..., (MM, 1); (1, 2), ..., (MM, 2); . . . .(MM, JM). The correspondence between angle number and direction is given by the S_n constants table in the output. Those fluxes, for an axial interval J and an angle M, for which MU(M) is negative, are for the left boundary, and those for which MU(M) is positive are for the right boundary.

(4) The next MM*IM words contain the outgoing angular fluxes at the top and bottom boundaries. The order of the fluxes is similar to that in the preceding item (3). In a similar manner the fluxes, for a radial interval I and an angle M, for which ETA(M) is positive are for the top boundary.

2.5.3 Angular Flux Tape

The angular flux tape contains the information required for two-dimensional perturbation codes, for input as a boundary source to subsequent DOT-IIW calculations, and for special analysis problems involving the angular flux. The sequence of information on the binary angular flux tape is as follows:

(1) The first record which is 72 words long contains a major portion of the DOT-IIW parameter block. The first 18 words are the title from the DOT-IIW case which may be printed under an 18A4 format. The remaining 54 words contain the parameters A01 through A15 in the order as arranged in COMMON.

(2) The next record contains the materials by zone, M2, an integer array, which is total number of zones (IZM) words in length.

(3) The third record contains the zone numbers by interval, M0 (K, J), an integer array which is number of intervals (IM*JM) words in length.

(4) The fourth record contains the fission spectrum, K7, which is number of groups (IGM) words in length.

(5) The fifth recrod contains the discrete ordinate quadrature weights, W0(M), which is number of angles (MM) words in length.

(6) The sixth record contains the Mu mates, M6(M), an integer array which is number of angles (MM) words in length.

(7) The next IGM (number of groups) records contain the $\nu\sum_f$ neutron production and $\sum_t$ cross sections by material. Each record is number of materials (MT*2) words in length.

(8) The next IGM*JM*2 records contain the angular fluxes. Each record is for a particular group and axial interval, J, and contains angular

fluxes by radial interval and angle for either the upward directed angles or downward directed angles. Each record is IM*T15 words where T15 is the number of angles in the upward or downward direction. The angles are arranged in the same order as the quadrature constants. The first angle for a downward directed set corresponds to the first angle in the quadrature; the first angle in an upward directed set corresponds to angle A05+1 in the quadrature. The records are arranged in the following order:

(a). Angular flux for J=JM, downward angles, group 1.

(b) Angular flux for J=JM-1, downward angles, group 1.

(c) Angular flux for J=1, downward angles, group 1.

(d) Angular flux for J=1, upward angles, group 1.

(e) Angular flux for J=JM, upward angles, group 1.

(f) Angular flux for J=JM, downward angles, group 2.

(g) Angular flux for J=JM, upward angles, group IGM

(9) The next record contains the volume elements, V0 (I, J) which is the number of intervals (IM*JM) words in length.

(10) The next record contains the radial coordinates, R1 (I), which are the number of radial mesh lines (IM+1) words in length.

(11) The last record contains the axial coordinates, Z1 (J), which are the number of axial mesh lines (JM+1) words in length.

2.6 PROGRAM LOGIC

The program logic for the DOT-IIW code is presented in this section. The presentation of the calculational procedure is given in a simplified form to show the user when a certain operation or calculation is performed.

2.6.1 Subroutine Description

The simplified flow chart of the major calculations performed by the DOT-IIW code is shown in Figure 2-5. For clarity, only the principal calculational routines are shown; the other routines are straightforward calculations or operations. Table 2-7 lists the subroutines in the DOT-IIW code and their functions.

To obtain more problem data space in core storage, the OVERLAY feature of the MSFC UNIVAC-1108 computer system is used. OVERLAY is a programming technique that minimizes the core storage requirements of the FORTRAN program. By minimizing the core storage required for the source program, more problem data space becomes available in core storage.

The level structure used in the overlay of the DOT-IIW code is shown in Figure 2-6. Levels are used to describe the sequence of loading overlays and to specify which sections of the source program overlay others. The main level of the overlay structure always resides in core storage. Only one primary level and its respective secondary levels can reside in core storage at one time.

An increase of approximately $16,000_{10}$ core storage locations for DOT-IIW problem data resulting in a total problem data storage of $51,000_{10}$ is achieved using the OVERLAY feature of the MSFC UNIVAC-1108 computer.

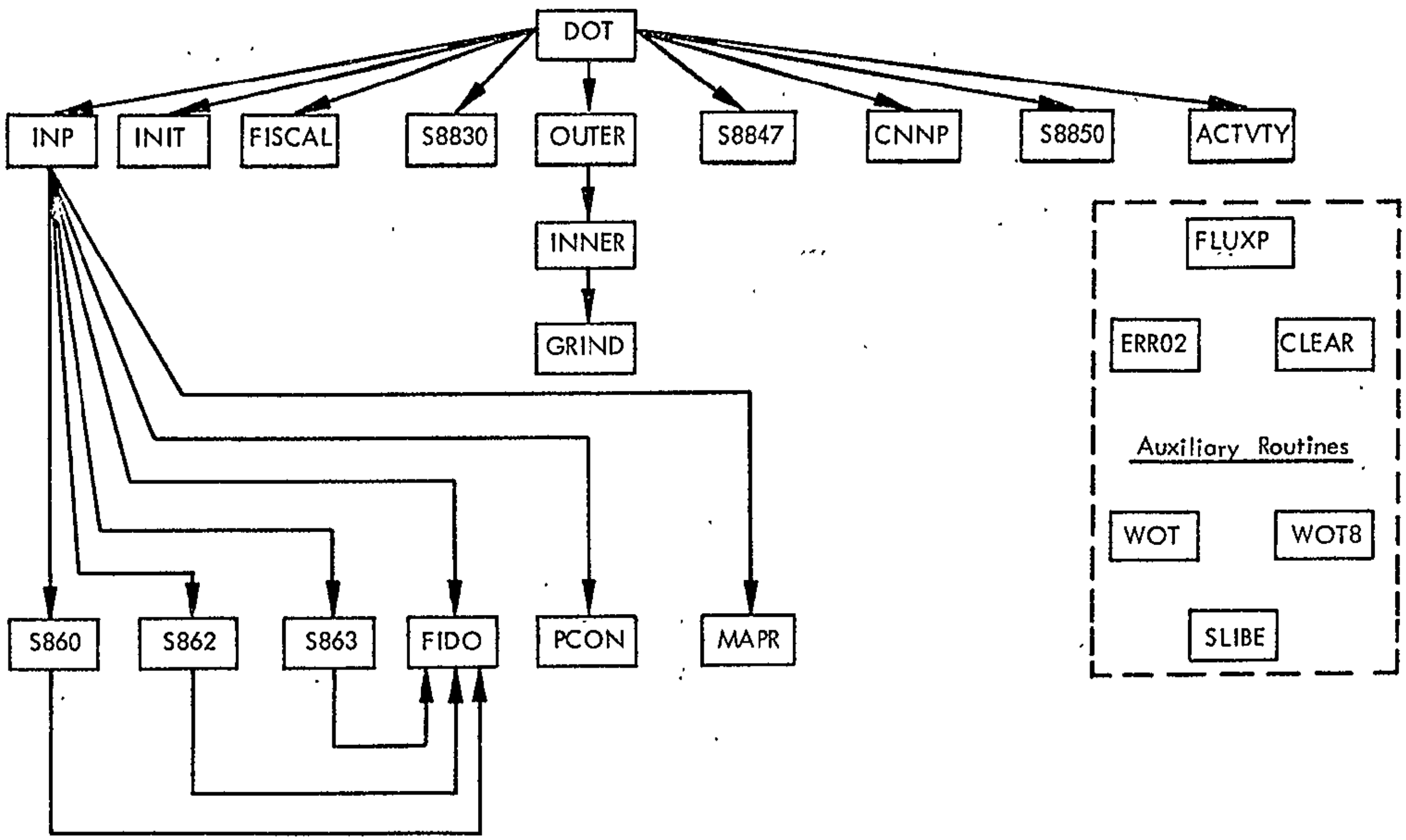


Figure 2-5. Flow Chart for the Two-Dimensional, Discrete Ordinate Transport Program, DOT-IIW

TABLE 2-7

LIST OF DOT-IIW CODE SUBROUTINES AND THEIR FUNCTION

Subroutine Name	Function
DOT	Overall Control of Program Information Flow
INP	Variable Dimension and Input Data Read Control
INIT	Initial Calculations and Setup
FISCAL	Fission Sum Calculation and Normalization
S8830	Monitor Line Printout
CNNP	Convergence Tests and Upscatter Scaling
S8847	Group Totals Calculation
OUTER	Outer Iteration Control
S8850	Final Print
ACTVTY	Activity Calculation
INNER	Inner Iteration Control
GRIND	Inner Iteration Calculation
S860	Reads Cross Sections
S862	Reads Fluxes and/or Distributed Source
S863	Reads Top or Right Boundary Source
FIDO	Generalized Input Data Read Routine
PCON	Calculates P_ℓ Coefficients
MAPR	Prints Picture Plot
ERR02	Writes Error Messages
CLEAR	Clears Discrete Areas of Core Storage
WOT	General Print Routine
WOT8	General Print Routine
SLIBE	Tape Cross Section Read Routine
FLUXP	Angular Flux Print

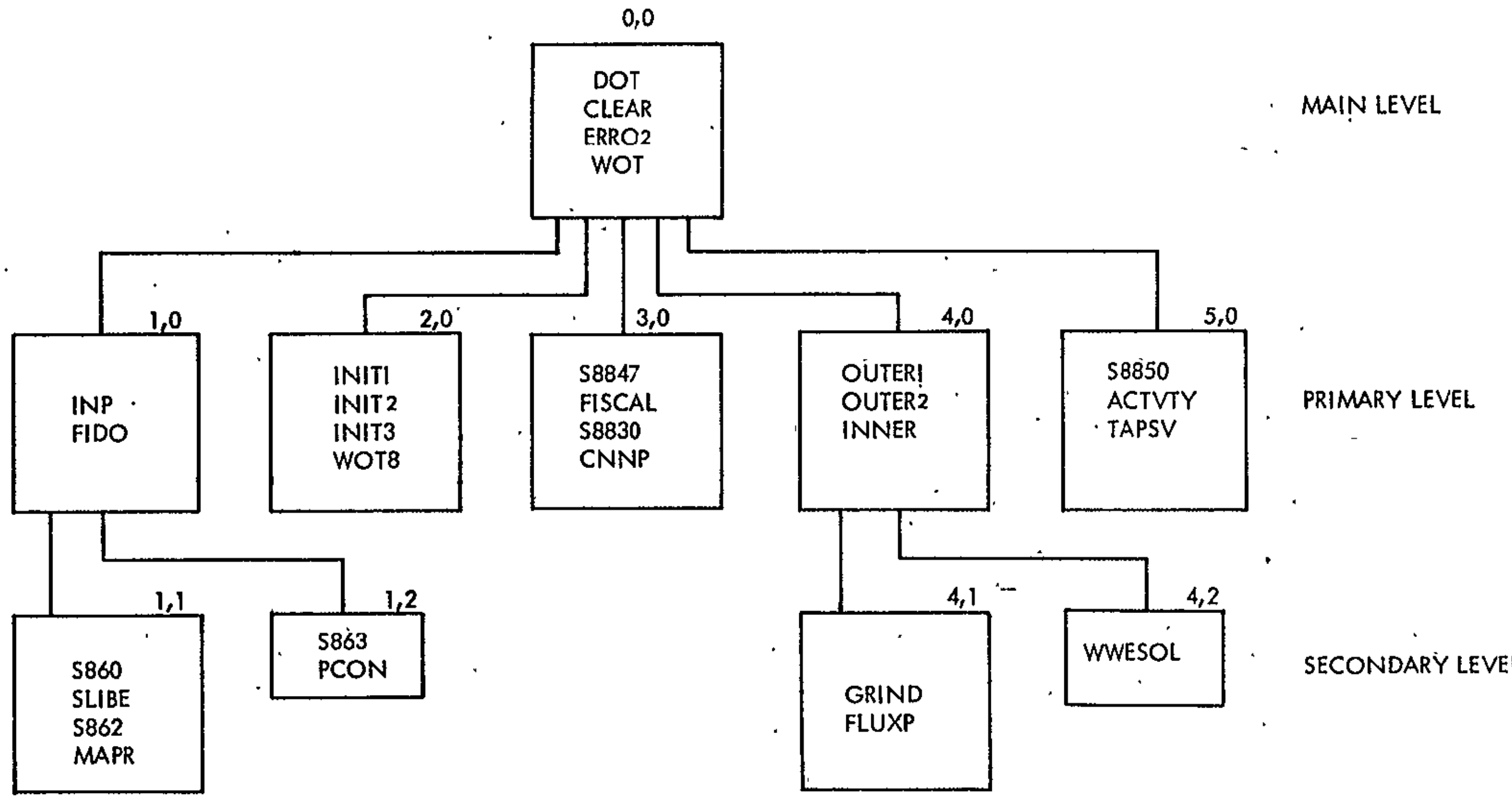


Figure 2-6. Overlay Structure for the DOT-IIW Code

2.7 METHOD OF SOLUTION

The user is referred to Reference 1 in which detailed equations are given describing the discrete ordinates transport solution of the Boltzmann transport equation used by the DOT-IIW code. Reference 2, 3, and 9 also contain pertinent information.

2.8 REFERENCES

1. F. R. Mynatt, F. J. Muckenthaler, and P. N. Stevens, CTC-INF-952, "Development of Two-Development of Two-Dimensional Discrete Ordinates Transport Theory for Radiation Shielding", August 1969.

2. K. D. Lathrop, LA-3373, "DTF-IV, a FORTRAN-IV Program for Solving the Multigroup Transport Equation with Anisotropic Scattering", November 1965.

3. C. E. Lee, LA-2595, "The Discrete S_n Approximation to Transport Theory", March 9, 1962.

4. B. G. Carlson, LA-3060, "A Method of Moments for Solving the Neutron Transport Equation", July 1964.

5. K. D. Lathrop and B. G. Carlson, LA-3186, "Discrete Ordinates Angular Quadrature of the Neutron Transport Equation", February 1965.

6. WANL-PR(LL)-010, "Synthesis of Calculational Methods for the Design and Analysis of Radiation Shields for Nuclear Rocket Systems", Volume 6, June 1967.

7. R. K. Disney and R. G. Soltesz, Internal Memorandum (RA-3611), "Mesh Spacing in Transport Codes", November 21, 1966.

8. Letter to Dr. A. Foderaro, Consultant for the Radiation and Shielding Group, from Glen E. Putnam, Senior Reactor Physicist, Phillips Petroleum Company, Number Put-6-65A, April 26, 1965. The letter describes the treatment of voids in S_n transport calculations.

9. ORNL-RSIC-19, "A Review of the Discrete Ordinates S_n Method for Radiation Transport Calculations", D. K. Trubey and Betty F. Maskewitz, Editors, March 1968.

10. W. W. Engle, Jr. and F. R. Mynatt, "A Comparison of Two Methods of Inner Iteration Convergence Acceleration in Discrete Ordinates Codes", Transactions of the American Nuclear Society Fourteenth Annual Meeting, Toronto, Canada, June 1968.

11. MSFC Staff, "Programmer Procedures Manual", Computation Laboratory, 1967 (and subsequent revisions).

4

3.0 MAP CODE

The MAP Code, as documented in WANL-TME-2706, August 1970, and entitled "Code Description and User's Manual for the MAP Radiation Transport Computer Code," is included in this Volume as APPENDIX C.

APPENDIX A
THE DOQ CODE

The discrete ordinates transport technique allows the user to compute many useful quantities. The transport of neutrons or photons through matter as a function of angle is one of these quantities. In the DOT-IIW transport code, the user specifies as input data, the discrete directions for which a solution is desired. As indicated in Section 2.2.4, these discrete directions cannot be chosen arbitrarily. Because the energy-angle relationship of the scatter cross sections used by the DOT-IIW code are represented by Legendre polynomials, quadrature sets that correctly integrate Legendre polynomials are required for particle conservation. In addition, symmetry conditions on discrete directions are important. The DOT-IIW code performs specific checks on these quadrature data to insure consistency. At least seven significant digits of precision for the input quadrature coefficients are required. For an S_{12} calculation, 288 coefficients and weights are required, for example.

To assist the DOT-IIW code user, the DOQ code was developed. The DOQ code computes the discrete ordinates quadrature coefficients (direction cosines and weights) given the point coordinates and symmetry conditions. A generalized technique using the method of moments is used. The code conveniently prints out and punches on cards the necessary quadrature coefficients for use in the one-dimensional, ANISN-W and two-dimensional, DOT-IIW codes.

The DOQ code was orginally developed as the SNAFU code by R. G. Rodgers, F. R. Mynatt, and W. W. Engle, Jr,* and subsequently modified by the authors. These modifications consist of 1) including variable dimensioning, 2) punched output compatible with the DOT-IIW, and ANISN-W codes, and 3) a different matrix solution algorithm.

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*Personnel of the Computer Technology Center, Union Carbide Nuclear Corporation, Oak Ridge, Tennessee.

A.1 COMPUTER CODE SYNOPSIS

1. Name: DOQ[1] (Discrete Ordinates Quadratures)

2. Computer: The codes is designed for the UNIVAC-1108 computer.

3. Nature of Physical Problem Solved: The DOQ code calculates discrete ordinates quadrature coefficients (direction cosines and weights) given the point coordinates and symmetry conditions.

4. Method of Solution: A generalized technique using the method of moments is used.[2,3]

5. Restrictions on the Complexity of the Problem: For almost all classes of calculations, no complexity restrictions are encountered. The only difficulty is in the choice of acceptable input point coordinates that yield non-negative quadrature weights.

6. Typical Running Time: Approximately ten quadrature set calculations ranging from S_4 to S_{20} were obtained in less than 60 CPU seconds.

7. Unusual Features of the Program: The code employs flexible dimensioning of data to allow high orders of quadrature to be calculated by efficient use of core memory storage.

8. Related or Auxiliary Programs: Data generated by the DOQ code may be used in the one-dimensional, ANISN-W[4] and the two-dimensional, DOT-IIW[1] discrete ordinates transport codes. Output from the DOQ code may also be used as input data to the ADOQ[1] asymmetric quadrature code.

9. Status: The code is in production use at the Marshall Space Flight Center (MSFC). Users at MSFC load the code from a disk or tape with control cards followed by the user's input data.

10. References:

1. R. G. Soltesz, R. K.Disney, J. Jedruch, and S. L. Zeigler, WANL-PR(LL)-034, Volume 5, "Two-Dimensional, Discrete Ordinates Transport Techniques," August 1970.
2. Bengt G. Carlson, LA-3060, "A Method of Moments for Solving the Neutron Transport Equation," February 1965.
3. K. D. Lathrop and B. G. Carlson, " LA-3186, "Discrete Ordinates Angular Quadrature of the Neutron Transport Equation," February 1965.

4. R. G. Soltesz and R. K. Disney, WANL-PR(LL)-034, Volume 4, "One-Dimensional, Discrete Ordinates Transport Technique," August 1970.

11. Machine Requirements: The DOQ code is in production at MSFC on the UNIVAC-1108 with 65 K core storage locations. The source program requires less than 10 K decimal locations; the remaining locations are used for problem data storage. One scratch tape or disk is required in addition to the input, output, and punch disk files.

12. Programming Language Used: The code is written standard, USASI FORTRAN-IV.

13. Operating System or Monitor Under Which Program is Executed: The DOQ code is operational under the EXEC8 Monitor System.

14. Other Programming or Operating Information or Restrictions: None

15. Name and Establishment of Authors:

R. G. Soltesz and R. K. Disney
Westinghouse Astronuclear Laboratory
P. O. Box 10864
Pittsburgh, Pa. 15236

A.2 INPUT DATA DESCRIPTION

All numerical data for the DOQ computer code are input in two standard, FORTRAN-IV formats in either a "right adjusted"* (I12) integer format, or an (E12.7) real (floating point) format. The user is referred to Section A.6 for an additional explanation of the terminology used in the description of the input data instructions given in Table A-1.

* "Right adjusted" means that the last significant digit of a number is at the extreme right of the field.

TABLE A-1

INPUT DATA INSTRUCTIONS FOR THE DOQ COMPUTER CODE

Card	Format	Column	Variable	Description
1	(6X, I6)	7 - 12	LIM1	The number of locations available for core data storage. LIM1 = 30000.*
2	(6I12)	1 - 12	NQD	Order of angular quadrature (even integer only, 2/4/6. . . ; $S_2/S_4/S_6$. . .)
		13 - 24	ISYM	Symmetry Condition, see Section A-6. ISYM = 1 No symmetry ISYM = 2 Half symmetry ISYM = 3 Complete symmetry
		25 - 36	LMRD	Moment Equation Option, see Section A-6 LMRD = 0 Calculate moment equations to be used (Suggested Option) LMRD = 1 Read in moment equations to be used
		37 - 48	IET	ETA Option, see Section A-6 IET = 0 Calculate η_i's based on input μ's (Suggested Option) IET = 1 Read in values of η_i's to be used.
		49 - 60	NMU	Complete Symmetry Option, see Section A-6 NMU = 0 Read in all μ_i's to be used. NMU = 1 Read in only μ_1 and use equations (6) and (7) in Section A-6 to calculate the other values of μ_i.
		61 - 72	IDEM	Punch Option and Geometry Option IDEM = 1 One-Dimensional Calculation

* The maximum value of LIM1 is determined by the maximum size of blank common set at code compile time.

TABLE A-1 (CONTINUED)

Card	Format	Column	Variable	Description
				IDEM = 2 Two-Dimensional Calculation if IDEM is positive, cards are punched if IDEM is negative, no cards are punched
3	(6E 12.7)	1 - 12, 13, - 24 etc.	MU(I)	Enter the values of μ. If NMU = 0, enter NQD/2 values If NMU = 1, enter μ_1 only
4	(6E 12.7)	1 - 12, 13, - 24 etc.	ETA(J)	Enter NQD/2 values of , if IET = 1 If IET = 0, omit this card.
5	(2I12)	1 - 12, 13, - 24	LR(I), MR (I)	Power of μ and η, respectively, to be used in the ith moment equation. See Section A-6. Omit this card if LMRD = 0. If entered, one value of LR and one value of MR are entered per card. Based on the number of equations to be solved (see Table A-3) a card is needed for each equation to be solved.

Note: Stacked cases are permitted starting with Card 2. Core data storage is set to zero for every calculation so that each case is a completely independent calculation.

A.3 PROBLEM SETUP INFORMATION

This section describes the data deck setup for the DOQ code. Information on tape assignments, running time, and error messages is provided.

A.3.1 Tape Assignments

The DOQ code has been placed on the MSFC UNIVAC-1108 computer under the EXEC8 Monitor System. Under this System, only one scratch tape or disk is required. The tape assignments are as follows:

Tape 5 Input Disk

Tape 6 Output Disk

Tape 7 Punch Disk

Tape 12 Scratch Disk for Matrix Solution

A.3.2 Running Time

The required running time for a given DOQ calculation on the UNIVAC-1108 is a function of the number of space angles in the solution. For a given S_n quadrature calculation of order n, the number of space angles is

$$SA = \frac{n(n+4)}{2}$$

The Central Processor Unit (CPU) time in almost all calculations is less than 20 seconds. The approximate CPU time required is

$$\text{CPU time (seconds)} = 0.2 \times SA$$

A.3.3 Error Messages

The following error messages may be encounterd:

	Message	Explanation
1.	"Illegal Guard Mode"	The value of LIM1 is too large for the specified field length
2.	"Data storage requirements exceed LIM1, check input"	Integer data on Card 2 are probably in the wrong column, or the value of LIM1 is probably in the wrong column.

	Message	Explanation
3.	"Insufficient number of available equations"	No solution is possible with the input set of data supplied.
4.	"ISUDS did 101 improvement iterations and did not meet the error criterion 1.0×10^{-9}	No solution is possible with the input set of data supplied; negative point weights will probably result.
5.	"Coefficient matrix is singular"	No solution possible with the input set of data supplied.

Error Messages 1 and 2 terminate the entire calculation on the UNIVAC-1108 computer, while Error Messages 3, 4, and 5 only terminate the particular calculation and any stacked case calculation is immediately begun.

A.3.4 Sample Problem Input

A listing of the input data for two sample problems for the DOQ code is shown in Table A-2. One quadrature calculation can require as few as three physical cards of input data, using the appropriate input data options.

A.3.5 Limitations

In performing DOQ computer code calculations, two types of limitations can be encountered; the first limitation occurs when the input set of μ_is and corresponding symmetry conditions yield simultaneous equations which are not all independent, or yield negative point weights, and the second limitation occurs due to insufficient core data storage space.

The first limitation is most often indicated by negative point weights, which are useless for DOT-IIW and ANISN-W calculations. Because of the generality of the method of solution, extreme care must be exercised in the selection of the μ_is and symmetry conditions; a set of quadrature cosines and positive weights could be generated having little technical justification. A careful review of the referenced reports will assist the user 1) in the proper selection of input parameters, 2) the geometrical conditions under which the quadrature data are best suited, and 3) specific, integral tests which the quadrature data must satisfy. No optimum type of quadrature data exists for all geometries and boundary conditions.[7]

TABLE A-2

SAMPLE PROBLEM CARD INPUT LISTING

```
    30000
       10         2         0         2         0         2
.97390652852.86506336669.67940956830.43339539413.14887433898
        6         2         0         2         0         2
.93246951420.66120938646.23861918608
```

The second limitation of insufficient core data storage space results from attempting to run too large a problem for the amount of data storage specified by the LIM1 card. With a 65K core available on the UNIVAC-1108, no difficulty is anticipated in this area. An S_{20} calculation, for example, required only 2589_{10} locations of the available $35{,}000_{10}$ core data storage locations. This efficient storage of data results from the use of flexible dimensions in the DOQ code.

In summary, a thorough beforehand knowledge of the equations solved by the DOQ computer code and their inherent limitations eliminates meaningless quadrature coefficient calculations.

A.4 DESCRIPTION OF OUTPUT

The printout from the sample problem input data presented in Section A.3.4 is shown in Table A-3. Printed output from the DOQ computer code consists of the following quantities:

1. The amount of variable dimension core storage required for this calculation,
2. A list of the input direction cosines (μ_i),
3. A tabulation of the equations used in the calculation,
4. The point diagram used in the calculation,
5. The maximum elementwise error by iteration in the solution of equation (15) in Section A.6,
6. The order of quadrature selected,
7. A tabulation of the initial direction cosines which are obtained from equation (18) in Section A.6,
8. A tabulation of the solution of equation (15) in Section A.6 and labeled "POINT WEIGHT, POINT WEIGHT/2, POINT WEIGHT/4.,"
9. A tabulation of the right-hand side of equation (9) in Section A.6 labeled "GAMMA EXPRESSION.,"
10. And, a tabulation of the μs, ηs, and ωs in the appropriate sequence for transport codes.

A.4.2 Punched Output

Punched card output from the DOQ computer code consists of the appropriate direction cosines and weights for either a one- or two-dimensional geometry transport calculation. If punched output is desired, IDEM is set equal to a +1 or a +2 for one- and two-dimensional geometries, respectively. If punched output is not desired, IDEM is set equal to a -1 or a -2 for the respective geometries.

For one-dimensional geometry calculations (IDEM = +1), the following data are punched on cards:

1. A 6U card containing a 6 punched in Column 2 and a U punched in Column 3,
2. Angular quadrature weights for cylindrical geometry in a FORTRAN (6F12.9) format,
3. A 7U card,
4. And angular quadrature direction cosines for cylindrical geometry in a FORTRAN (6F12.9) format.

For two-dimensional geometry calculations (IDEM = +2), the following data are punched on cards:

1. A 7U card,
2. Angular quadrature direction cosines, (μ_is), in a FORTRAN (6F12.9) format,
3. Angular quadrature direction cosines, (η_is), in a FORTRAN (6F12.9) format,
4. A T card,
5. A 6U card,
6. Angular quadrature weights in a FORTRAN (6F12.9) format, and
7. A T card.

TABLE A-3

SAMPLE PROBLEM COMPUTER PRINTOUT

```
DATA STORAGE REQUIREMENT =     585

MU( 1) = 9.7390652852E-01
MU( 2) = 8.6506336669E-01
MU( 3) = 6.7940956830E-01
MU( 4) = 4.3339539413E-01
MU( 5) = 1.4887433898E-01

EQUATIONS USED          L          M
                        0          0
                        2          0
                        4          0
                        6          0
                        8          0
                        2          2
                        4          2
                        6          2
                        4          4

POINT DIAGRAM

   1
   2    6
   3    7    9
   4    8    7    6
   5    4    3    2    1
 ERROR = 9.89196E-01
 ERROR = 2.88537E-14
 ERROR = 5.37373E-27

 S 10 CONSTANTS

 INITIAL DIRECTIONS

 9.88856123E-01
 9.01203879E-01
 7.33759251E-01
 5.01662607E-01
 2.26949496E-01

POINT          POINT WEIGHT          POINT WEIGHT/2          POINT WEIGHT/4

   1           6.66713443E-02        3.33356722E-02          1.66678361E-02
   2           5.16836007E-02        2.58418003E-02          1.29209002E-02
   3           7.68425476E-02        3.84212738E-02          1.92106369E-02
   4           2.74264350E-02        1.37132175E-02          6.85660874E-03
   5           7.29002971E-02        3.64501486E-02          1.82250743E-02
```

TABLE A-3 (CONTINUED)

6	9.77677485E-02	4.88838742E-02	2.44419371E-02
7	3.41993192E-02	1.70996596E-02	8.54982980E-03
8	1.09873217E-01	5.49366083E-02	2.74683042E-02
9	1.08044496E-01	5.40222478E-02	2.70111239E-02

TABLE A-3 (CONTINUED)

L	M	SUM	GAMMA EXPR
0	0	1.00000000E+00	1.00000000E+00
2	0	3.33333333E-01	3.33333333E-01
4	0	2.00000000E-01	2.00000000E-01
6	0	1.42857143E-01	1.42857143E-01
8	0	1.11111111E-01	1.11111111E-01
2	2	6.66666667E-02	6.66666667E-02
4	2	2.85714286E-02	2.85714286E-02
6	2	1.58730159E-02	1.58730159E-02
4	4	9.52380952E-03	9.52380952E-03

	MU	ETA	WEIGHT
1	-2.26949496E-01	-9.73906529E-01	0.
2	-1.48874339E-01	-9.73906529E-01	1.66678361E-02
3	1.48874339E-01	-9.73906529E-01	1.66678361E-02
4	-5.01662607E-01	-8.65063367E-01	0.
5	-4.33395394E-01	-8.65063367E-01	2.44419371E-02
6	-1.48874339E-01	-8.65063367E-01	1.29209002E-02
7	1.48874339E-01	-8.65063367E-01	1.29209002E-02
8	4.33395394E-01	-8.65063367E-01	2.44419371E-02
9	-7.33759251E-01	-6.79409568E-01	0.
10	-6.79409568E-01	-6.79409568E-01	2.70111239E-02
11	-4.33395394E-01	-6.79409568E-01	8.54982980E-03
12	-1.48874339E-01	-6.79409568E-01	1.92106369E-02
13	1.48874339E-01	-6.79409568E-01	1.92106369E-02
14	4.33395394E-01	-6.79409568E-01	8.54982980E-03
15	6.79409568E-01	-6.79409568E-01	2.70111239E-02
16	-9.01203879E-01	-4.33395394E-01	0.
17	-8.65063367E-01	-4.33395394E-01	2.44419371E-02
18	-6.79409568E-01	-4.33395394E-01	8.54982980E-03
19	-4.33395394E-01	-4.33395394E-01	2.74683042E-02
20	-1.48874339E-01	-4.33395394E-01	6.85660874E-03
21	1.48874339E-01	-4.33395394E-01	6.85660874E-03
22	4.33395394E-01	-4.33395394E-01	2.74683042E-02
23	6.79409568E-01	-4.33395394E-01	8.54982980E-03
24	8.65063367E-01	-4.33395394E-01	2.44419371E-02
25	-9.88856123E-01	-1.48874339E-01	0.
26	-9.73906529E-01	-1.48874339E-01	1.66678361E-02
27	-8.65063367E-01	-1.48874339E-01	1.29209002E-02
28	-6.79409568E-01	-1.48874339E-01	1.92106369E-02
29	-4.33395394E-01	-1.48874339E-01	6.85660874E-03
30	-1.48874339E-01	-1.48874339E-01	1.6225[illegible]743E-02
31	1.48874339E-01	-1.48874339E-01	1.6225[illegible]743E-02
32	4.33395394E-01	-1.48874339E-01	6.85660874E-03
33	6.79409568E-01	-1.48874339E-01	1.92106369E-02
34	8.65063367E-01	-1.48874339E-01	1.29209002E-02
35	9.73906529E-01	-1.48874339E-01	1.66678361E-02

TABLE A-3 (CONTINUED)

36	-2.26949496E-01	9.73906529E-01	0.
37	-1.48874339E-01	9.73906529E-01	1.66678361E-02
38	1.48874339E-01	9.73906529E-01	1.66678361E-02
39	-5.01662607E-01	8.65063367E-01	0.
40	-4.33395394E-01	8.65063367E-01	2.44419371E-02
41	-1.48874339E-01	8.65063367E-01	1.29209002E-02
42	1.48874339E-01	8.65063367E-01	1.29209002E-02
43	4.33395394E-01	8.65063367E-01	2.44419371E-02
44	-7.33759251E-01	6.79409568E-01	0.
45	-6.79409568E-01	6.79409568E-01	2.70111239E-02
46	-4.33395394E-01	6.79409568E-01	8.54982980E-03
47	-1.48874339E-01	6.79409568E-01	1.92105369E-02
48	1.48874339E-01	6.79409568E-01	1.92105369E-02
49	4.33395394E-01	6.79409568E-01	8.54982980E-03
50	6.79409568E-01	6.79409568E-01	2.70111239E-02
51	-9.01203879E-01	4.33395394E-01	0.
52	-8.65063367E-01	4.33395394E-01	2.44419371E-02
53	-6.79409568E-01	4.33395394E-01	8.54982980E-03
54	-4.33395394E-01	4.33395394E-01	2.74683042E-02
55	-1.48874339E-01	4.33395394E-01	6.85660874E-03
56	1.48874339E-01	4.33395394E-01	6.85660874E-03
57	4.33395394E-01	4.33395394E-01	2.74683042E-02
58	6.79409568E-01	4.33395394E-01	8.54982980E-03
59	8.65063367E-01	4.33395394E-01	2.44419371E-02
60	-9.88561123E-01	1.48874339E-01	0.
61	-9.73906529E-01	1.48874339E-01	1.66678361E-02
62	-8.65063367E-01	1.48874339E-01	1.29209002E-02
63	-6.79409568E-01	1.48874339E-01	1.92105369E-02
64	-4.33395394E-01	1.48874339E-01	6.85660874E-03
65	-1.48874339E-01	1.48874339E-01	1.82250743E-02
66	1.48874339E-01	1.48874339E-01	1.82250743E-02
67	4.33395394E-01	1.48874339E-01	6.85660874E-03
68	6.79409568E-01	1.48874339E-01	1.92105369E-02
69	8.65063367E-01	1.48874339E-01	1.29209002E-02
70	9.73906529E-01	1.48874339E-01	1.66678361E-02

TABLE A-3 (CONTINUED)

```
DATA STORAGE REQUIREMENT =    239

MU( 1) = 9.3246951420E-01
MU( 2) = 6.6120938646E-01
MU( 3) = 2.3861918608E-01

EQUATIONS USED          L          M
                        0          0
                        2          0
                        4          0
                        2          2

POINT DIAGRAM

   1
   2   4
   3   2   1
 ERROR = 9.77905E-01
 ERROR = 1.25185E-16
 ERROR = 0.

 S  6 CONSTANTS

 INITIAL DIRECTIONS

 9.71113219E-01
 7.50201404E-01
 3.61248675E-01
```

POINT	POINT WEIGHT	POINT WEIGHT/2	POINT WEIGHT/4
1	1.71324492E-01	8.56622462E-02	4.28311231E-02
2	1.39806894E-01	6.99034470E-02	3.49517235E-02
3	1.56782548E-01	7.83912740E-02	3.91956370E-02
4	2.20954679E-01	1.10477339E-01	5.52386697E-02

TABLE A-3 (CONTINUED)

L	M	SUM	GAMMA EXPR
0	0	1.00000000E+00	1.00000000E+00
2	0	3.33333333E-01	3.33333333E-01
4	0	2.00000000E-01	2.00000000E-01
2	2	6.66666667E-02	6.66666667E-02

	MU	ETA	WEIGHT
1	-3.61248675E-01	-9.32469514E-01	0.
2	-2.38619186E-01	-9.32469514E-01	4.28311231E-02
3	2.38619186E-01	-9.32469514E-01	4.28311231E-02
4	-7.50201404E-01	-6.61209386E-01	0.
5	-6.61209386E-01	-6.61209386E-01	5.52386697E-02
6	-2.38619186E-01	-6.61209386E-01	3.49517235E-02
7	2.38619186E-01	-6.61209386E-01	3.49517235E-02
8	6.61209386E-01	-6.61209386E-01	5.52386697E-02
9	-9.71113219E-01	-2.38619186E-01	0.
10	-9.32469514E-01	-2.38619186E-01	4.28311231E-02
11	-6.61209386E-01	-2.38619186E-01	3.49517235E-02
12	-2.38619186E-01	-2.38619186E-01	3.91956370E-02
13	2.38619186E-01	-2.38619186E-01	3.91956370E-02
14	6.61209386E-01	-2.38619186E-01	3.49517235E-02
15	9.32469514E-01	-2.38619186E-01	4.28311231E-02
16	-3.61248675E-01	9.32469514E-01	0.
17	-2.38619186E-01	9.32469514E-01	4.28311231E-02
18	2.38619186E-01	9.32469514E-01	4.28311231E-02
19	-7.50201404E-01	6.61209386E-01	0.
20	-6.61209386E-01	6.61209386E-01	5.52386697E-02
21	-2.38619186E-01	6.61209386E-01	3.49517235E-02
22	2.38619186E-01	6.61209386E-01	3.49517235E-02
23	6.61209386E-01	6.61209386E-01	5.52386697E-02
24	-9.71113219E-01	2.38619186E-01	0.
25	-9.32469514E-01	2.38619186E-01	4.28311231E-02
26	-6.61209386E-01	2.38619186E-01	3.49517235E-02
27	-2.38619186E-01	2.38619186E-01	3.91956370E-02
28	2.38619186E-01	2.38619186E-01	3.91956370E-02
29	6.61209386E-01	2.38619186E-01	3.49517235E-02
30	9.32469514E-01	2.38619186E-01	4.28311231E-02

A.5 PROGRAM LOGIC

The program logic for the DOQ code is presented in this section. The presentation of the calculational procedure is given in a simplified form to show the user when a certain operation or calculation is performed.

A.5.1 Subroutine Description

The simplified, flow chart of the major calculations performed by the DOQ code is shown in Figure A-1. Table A-4 lists the subroutines in the DOQ code and their function.

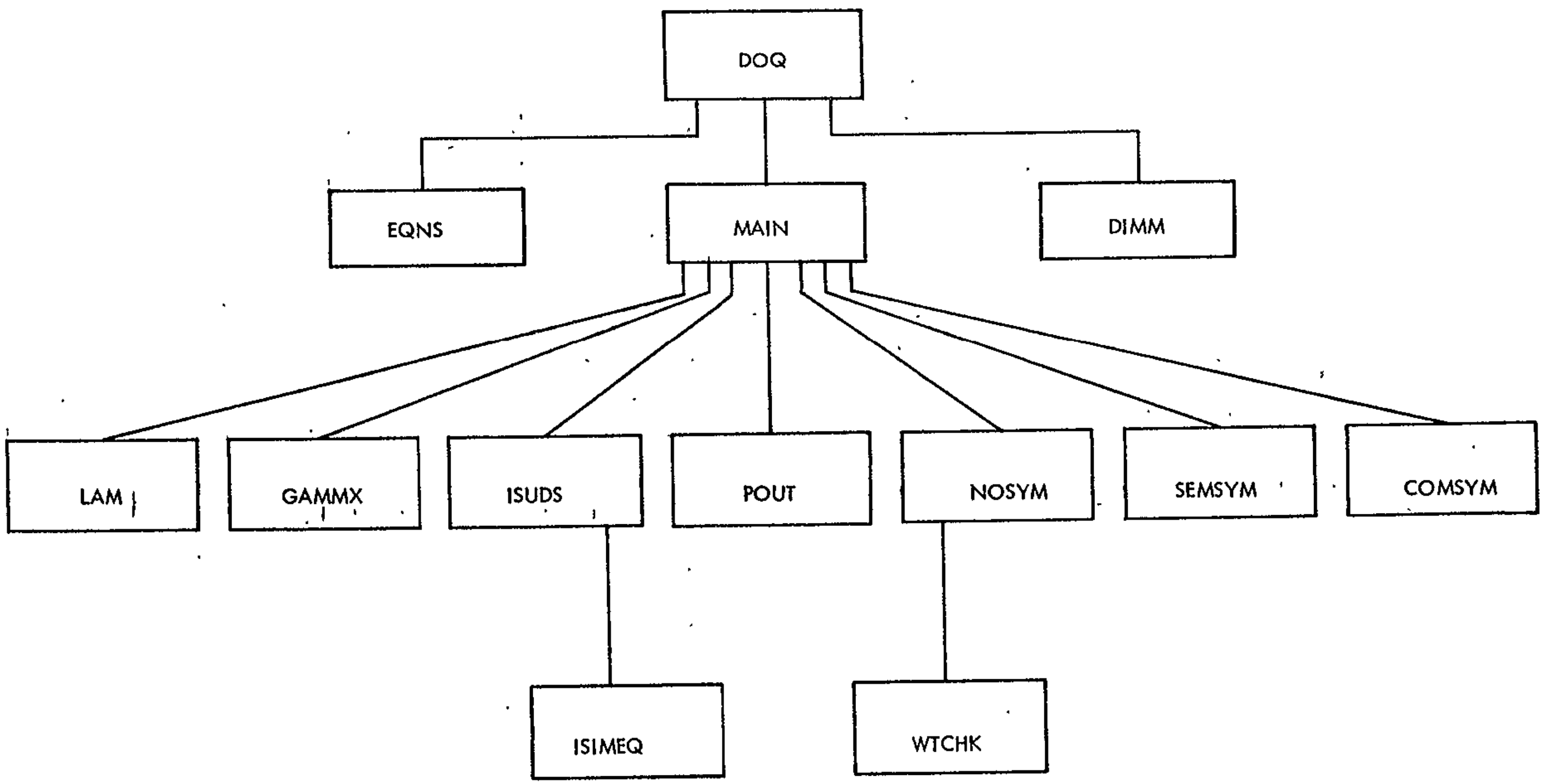


Figure A-1. Flow Chart for the DOQ Code

TABLE A-4

LIST OF DOQ CODE SUBROUTINES AND THEIR FUNCTION

Subroutine Name	Function
DOQ	Compute variable dimension storage allocation and initialize core storage
MAIN	Reads input data, controls the selection of the required equations, computes the point moments, prints the point diagram, sets up the matrix equation, prints out final direction cosines and weights
EQNS	Calculates the number of unknowns and the number of required equations for the variable dimension storage allocation
LAM	Selects the individual moment equations
NOSYM	Converts point moments to equation constants for calculations with no symmetry
SEMSYM	Converts point moments to equation constants for calculations with half symmetry
COMSYM	Converts point moments to equation constants for calculations with complete symmetry
POUT	Arranges cosines and constants in correct order for punching on cards
WTCHK	Prints out the left- and right-hand side of Equation (9) by term, punches out the results
GAMMX	Computes the gamma function
DIMM	Performs a preliminary variable dimension calculation
ISUDS	Iterative matrix solution using a direction solution
ISIMEQ	Gauss-elimination direct solution of matrix equation

A. 6 METHOD OF SOLUTION

The DOQ computer code calculates direction cosines and weights using a generalized method of moments.(1) In this method, direction cosine sets can be chosen arbitrarily. Once the direction cosine sets are chosen, the quadrature weights are found by satisfying a general set of moments.(2)

The coordinate system and unit sphere in cylindrical geometry(3) for the DOQ code is shown in Figure A-2. In this geometry, the coordinates, (r,z,θ) define the point in space; z, r, and θ are the coordinate axes of the unit sphere; and η, μ, and ξ are the direction cosines defining a point on the unit sphere and the direction, $\vec{\Omega}$. Figure A-3 shows an S_n arrangement (for n = 6) for a completely symmetric quadrature set. Because of symmetry, a description of one octant suffices to describe the arrangement of points on the unit sphere. Because these points lie on the unit sphere:

(1) $$\mu_3^2 + \eta_1^2 + \xi_1^2 = 1$$

(2) $$\mu_2^2 + \eta_1^2 + \xi_2^2 = 1$$

$$\vdots$$

or, since the coordinates are from the same set, (i. e., $\eta_i = f(\mu_i)$):

(3) $$\mu_3^2 + 2\mu_1^2 = 1$$

(4) $$2\mu_2^2 + \mu_1^2 = 1$$

Because of the complete symmetry, the indices, i, j, k, of the coordinates of a point on the sphere sum to n/2 + 2. That is, in general,

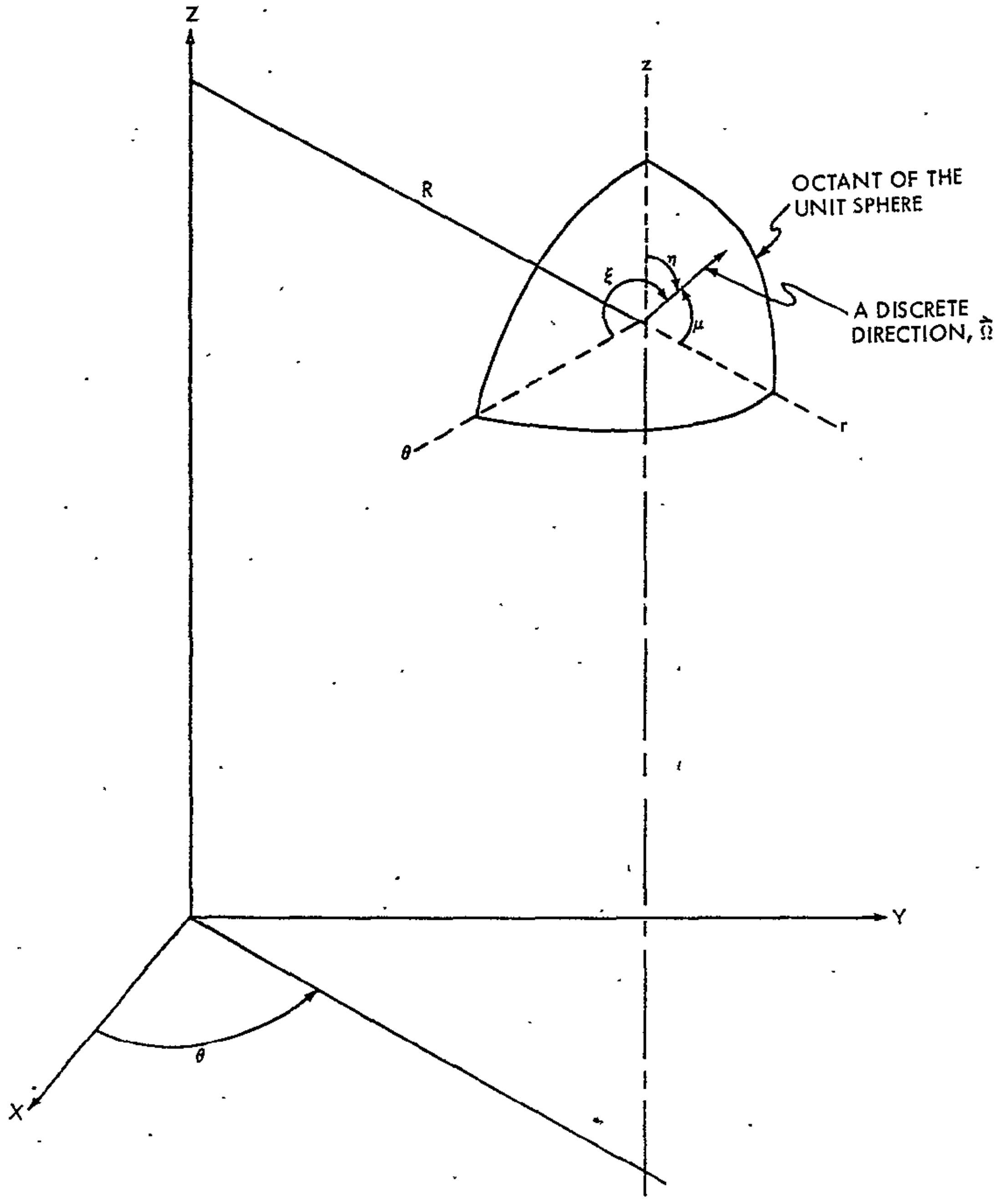


Figure A-2. Coordinate System for the DOQ Code

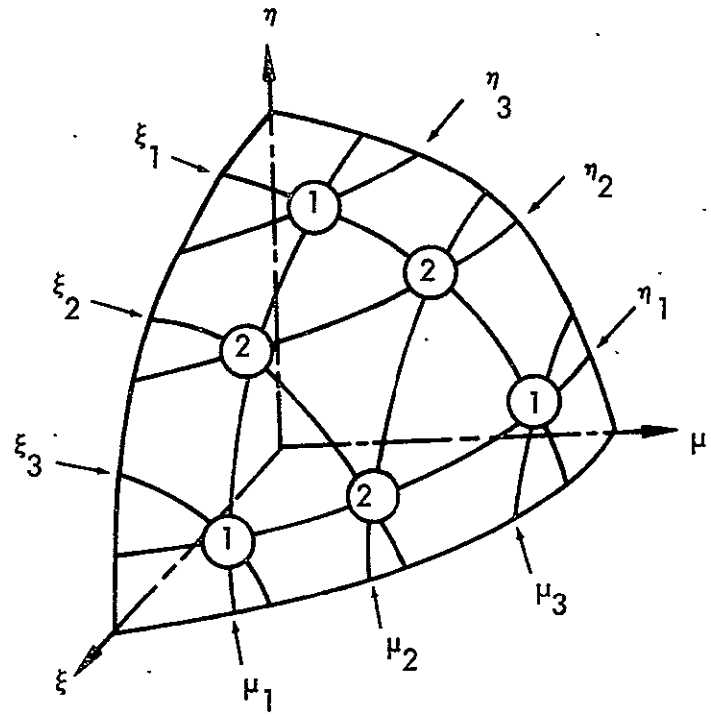


Figure A-3. Completely Symmetric S_n Arrangement (for n = 6)

(5) $$\mu_i^2 + \mu_j^2 + \mu^2_{n/2+2-i-j} = 1.0$$

where $i = 1, 2, \ldots, n/2;\ j = 1, 2, \ldots, n/2 - i + 1$

Equation (5) is solved by:[4]

(6) $$\mu_i^2 = \mu_1^2 + (i-1)\Delta \text{ for } i = 1, 2, \ldots, n/2$$

where:

(7) $$\Delta = 2(1 - 3\mu_1^2)/(n-2)$$

Hence, the requirement of complete symmetry fixes all μ_i except μ_1, and the freedom of Gaussian quadrature is not present in this case. The DOQ computer code allows the user to specify μ_1, if desired, and uses eq. (6) to determine the needed direction cosine sets

In cylindrical geometry, the requirement that the quadrature coefficients and weights integrate certain orders of polynomials of the direction cosines is desirable.

From this requirement, the following moment equation can be expressed:

(8) $$\sum_{k=1}^{K} \mu_k^l \, {}_k^m \, {}_k = \frac{2}{\pi} \int_0^{\pi/2} \int_0^1 \mu^l \, \eta^m \, d\mu \, d\psi$$

where K is the Sn quadrature order, n. The quantities, μ_k and η_k are the k^{th} direction cosines on the unit sphere, raised to the l^{th} and m^{th} power, respectively. The evaluation of eq. (8) yields:

(9) $$\Psi_{l,m} = \sum_{k=1}^{K} P_k \mu_i^l \, \eta_j^m = \frac{1/2 \; \Gamma\left(\frac{l+1}{2}\right) \Gamma\left(\frac{m+1}{2}\right)}{\Gamma(1/2)\, \Gamma\left(\frac{l+m+3}{2}\right)}$$

where $\Gamma(x)$ is the gamma function $= \int_0^\infty t^{x-1} \cdot e^{-t} \, dt$

for which $\Gamma(1/2) = \sqrt{\pi}$ and $\Gamma(X+1) = \Gamma(X)$.

and P_k = k^{th} point weight

μ_i, η_j = direction cosines determining the k^{th} point

$l, m = 0, 2, 4, \ldots$

Equation (9) is evaluated in the DOQ computer code. A short table of $\Psi l, m$ is shown below including entries for odd values of m (Odd values of l and m are disallowed in this formalism, but are shown below for completeness).

	l	m=0	1	2	3	4	5	6	7
	0	1	1/2	1/3	1/4	1/5	1/6	1/7	1/8
(10)	2	1/3	1/8	1/15	1/24	1/35	1/48	1/63	1/80
	4	1/5	1/16	1/35	1/64	1/105	1/160	1/231	.
	6	1/7	5/128	1/63	1/128	1/231	1/384	.	.
	8	1/9	7/256	1/99	7/768	.	.	.	.

In the DOQ computer code, l and m must be even and are restricted by the condition:

(11) $l + m < n$ for $n = 2, 4, 6 \ldots$ (e.g., S_8, $n = 8$)

By restricting l and m to even integers, the quadrature data obtained by the solution of Equation (9) satisfy even moment conditions. In addition, the restriction in Equation (11) insures that independent equations will be selected for the solution of Equation (9). Given a set of direction cosines (with $\mu_i^2 + \eta_j^2 + \xi_k^2 = 1$), the system of equations may be placed in the following triangular array applicable to a quadrature scheme of order "n."

(12)

$$
\begin{array}{llllll}
 & m \longrightarrow & & & & \\
\psi_{0,0} & \psi_{0,2} & \psi_{0,4} & \psi_{0,6} & \ldots & \psi_{0,n-2} \\
\psi_{2,0} & \psi_{2,2} & \psi_{2,4} & \cdot & \cdot & \cdot \\
\psi_{4,0} & \psi_{4,2} & \cdot & \cdot & & \\
\psi_{6,0} & \cdot & \cdot & \cdot & & \\
\cdot & & & & & \\
\cdot & & & & & \\
\psi_{n-2,0} & & & & &
\end{array}
\quad l \downarrow
$$

The diagonal line drawn in eq. (12) above for S_6 (or n = 6) separates the pairs for independent moments (above the line) from the pairs for dependent moments. To find the point weights for a given quadrature order, equations are selected from this array. The programmed order of selection in the DOQ computer code is to hold m constant and take equations of increasing l starting with l = m. The code then increments m by two and the process is repeated with l = m. After the upper left portion of the array is exhausted in this procedure, l is then held constant, and equations with increasing m are selected.

The code increments l until, if necessary, the entire array is utilized. For example, for an S_8 quadrature with no symmetry, the order of equations selected would be;

(13) $\Psi_{00}, \quad \Psi_{20}, \quad \Psi_{40}, \quad \Psi_{60}, \quad \Psi_{22}, \quad \Psi_{42}, \quad \Psi_{02}, \quad \Psi_{04}, \quad \Psi_{06}, \quad \Psi_{24}.$

With complete symmetry, Ψ_{20} degenerates to Ψ_{00}, hence in subroutine COMSYM, Ψ_{20} is bypassed for fully symmetric calculations.

The user may input the order of selection of the equations used in equation (9), if desired.

In the DOQ computer code, the values of μ_i and symmetry conditions are read in. The values of η_i may be read in if desired, but, in general, they should not be input. The code will set η_i equal to μ_i for all i.

It is now desirable to define how many equations are required by the DOQ computer code for a given order of angular quadrature with a given symmetry condition. Table A-5 shows, for a given qudrature order and given summetry condition, how many simultaneous equations are required for equation (9). The maximum index that appears in a given point diagram indicates the number of equations that are required. To illustrate, consider n= 2. Then $P_1 = 1$ is the single equation to be solved. When n = 4, there are three weights and three equations with no symmetry:

(13)
$$\begin{aligned} \Psi\ 0,0: &\quad P_1 + P_2 + P_3 = 1 \\ \Psi\ 2,0: &\quad P_1 \mu_1^2 + P_2 \mu_2^2 + P_3 \mu_1^2 = 1/3 \\ \Psi\ 0,2: &\quad P_1 \eta_1^2 + P_2 \eta_1^2 + P_3 \eta_1^2 = 1/3 \end{aligned}$$

TABLE A-5

POINT DIAGRAM FOR VARIOUS QUADRATURE COMBINATIONS

Complete Symmetry	Half Symmetry	No Symmetry
	S_4	
1	1	3
1 1	2 1	2 1
	S_6	
1	1	6
2 2	2 2	5 3
1 2 1	3 2 1	4 2 1
	S_8	
1	1	10
2 2	2 2	9 6
2 3 2	3 4 2	8 5 3
1 2 2 1	4 3 2 1	7 4 2 1
	S_{10}	
1	1	15
2 2	2 6	14 10
3 4 3	3 7 9	13 9 6
2 4 4 2	4 8 7 6	12 8 5 3
1 2 3 2 1	5 4 3 2 1	11 7 4 2 1
	S_{12}	
1	1	21
2 2	2 7	20 15
3 4 3	3 8 11	19 14 10
3 5 5 3	3 9 12 11	18 13 9 6
2 4 5 4 2	5 10 9 8 7	17 12 8 5 3
1 2 3 3 2 1	6 5 4 3 2 1	16 11 7 4 2 1

Given the direction μ_i and η_i, the above set of simultaneous, independent equations can be solved for three point weights. The above development also includes the half-symmetric and the completely symmetric case as well. Equation (13) can be rewritten in matrix notation[5] as follows:

(14)
$$\begin{bmatrix} 1 & 1 & 1 \\ \mu_1^2 & \mu_1^2 & \mu_1^2 \\ \eta_1^2 & \eta_1^2 & \eta_1^2 \end{bmatrix} \times \begin{bmatrix} P1 \\ P2 \\ P3 \end{bmatrix} = \begin{bmatrix} 1 \\ 1/3 \\ 1/3 \end{bmatrix}$$

or simply

(15) $$AX=B$$

There are many ways to solve equation (15). The method used in the DOQ computer code is an iterative scheme using a direct Gaussian elimination solution and is contained in the subroutines ISUDS[6] and ISIMEQ.

The solution algorithm requires that:

(16)
$$\left| \frac{x_{i+1}^m - x_i^m}{x_i^m} \right| < \text{ESP}$$

where $i+1$ is the present iteration and x is the mth element in X

In the DOQ computer code, ESP has been set at 1.0×10^{-9} which is believed sufficiently precise for application to quadrature weight calculations.

Finally, the gamma function, $\Gamma(\alpha)$, defined by:

(17)
$$\Gamma(\alpha) = \int_0^{\infty} t^{\alpha - 1} \cdot e^{-t} \, dt$$

and used in equation(9) had to be evaluated. In the original version of the code, the gamma function subroutine was obtained from the system tape; however, this subroutine does not exist on all computer system tapes. It was decided to use the IBM Scientific Subroutine Package report to solve equation (17). The recursion relation and polynomial approximation method was chosen and a maximum relative error of 1.0×10^{-9} was selected for the convergence criteria. Because the evaluation of equation (9) yields the fractions given in equation (10), checkout of the accuracy of the gamma function calculation was straightforward.

The jth initial direction cosines are calculated from the input set of μ_i values using the relation:

$$\mu_j^2 = \sqrt{1 - \mu_i^2}$$

where:
$i = 1, \; j = n$
$i = 2, \; j = n-1$
$\vdots \qquad \vdots$
$i = n-1, \; j = 2$
$i = n, \; j = 1$

After the point weights are calculated, the distribution and tabulation of weights and cosines in the appropriate form constitutes the remainder of the calculations.

A.7 REFERENCES

1. Bengt G. Carlson, "A Method of Moments for Solving the Neutron Transport Equation," LA-3060, February 8, 1965.

2. K. D. Lathrop and B. G. Carlson, "Discrete Ordinates Angular Quadrature of the Neutron Transport Equation," LA-3186, February 12, 1965.

3. Clarence E. Lee, "The Discrete S_n Approximation to Transport Theory," LA-2595, March 9, 1962.

4. B. G. Carlson and C. E. Lee, "Mechanical Quadrature and the Transport Equation," LAMS-2573, 1961.

5. Charles Cullen, Matrices and Linear Transformations, Addison-Wesley Publishing Company, 1966.

6. George Collier, "ISUDS - Iterative Scheme Using a Direct Solution," WANL-TME-1515, September 1966.

7. H. Greenspan, C. N. Keller, and D. Okrent, Editors, Computing Methods in Reactor Physics, Chapter 3, Gordon and Breach Science Publishers, 1968.

APPENDIX B

THE ADOQ CODE

The importance of accurately predicting the nuclear radiation environment and radiation transport external to a nuclear reactor system has necessitated the development of asymmetric quadrature techniques for use in discrete ordinate transport analyses. These two-dimensional, transport theory techniques have significantly reduced "ray effects"(1) and have provided increased angular resolution of the spatially attenuated nuclear subsystem leakage spectrum. When conventional symmetric quadrature transport techniques are used to calculate the radiation transport through low-scattering media or voids, "ray effects" are observed with low order quadratures. These "ray effects," or anomalous computational results, are due to the discrete representation of the angular variable in discrete ordinate transport theory approximations and predict preferential radiation streaming along the discrete directions of angular quadrature chosen.

Accurate angular resolution of the spatially attenuated leakage spectrum at locations far removed from the nuclear system is also important in the prediction of neutron thermalization in local media for the calculation of secondary gamma ray sources.

Analytical radiation transport techniques have been developed to satisfy both of these requirements. The method consists of 1) the development(2) of asymmetric quadrature data using the DOQ and ADOQ computer codes to achieve a high degree of angular resolution along the axis and in the solution plane of interest; 2) the modification of the DOT two-dimensional, discrete ordinate transport code to use these data; and 3) the development and coding of the MAP code to reconstruct the angular and energy dependence of the neutron or photon flux as a function of position external to the nuclear system using the reactor surface angular fluxes from the DOT code as input data.

In addition, techniques in the MAP code for processing asymmetric quadrature data at the reactor surface and providing asymmetric quadrature angular flux at the surface of a succeeding DOT problem of a medium separated from the reactor have been developed.

A particular set of asymmetric quadrature data generated by the ADOQ code has been successfully used which provides a polar angular resolution on the order of one degree between 0 and 17.5 degrees, contains an S_{10} Gaussian quadrature from 17.5 to 90 degrees, and contains a completely symmetric S_6 quadrature from 90 to 180 degrees. In addition, azimuthal angle resolution is asymmetric in the polar angle from 0 to 17.5 degrees. The MAP code, using the asymmetric quadrature surface angular flux tape from the DOT-IIW code, performs a rapid numerical integration over the visible surface of the reactor system and provides inverse square attenuation to obtain the angle-energy relationship of the flux at locations external to the nuclear system.

The ADOQ code is a technique for 1) combining asymmetric quadrature data with symmetric quadrature data in one hemisphere of the unit S_n sphere, 2) adjusting the level weights of the last asymmetric level to match the symmetric level, and 3) verifying the various relationships these data must satisfy.

B.1 COMPUTER CODE SYNOPSIS

1. Name: ADOQ[1] (Asymmetric Discrete Ordinate Quadrature)
2. Computer: The code is designed for the UNIVAC-1108
3. Nature of Physical Problem Solved: The ADOQ code prepares asymmetric quadrature sets with a high density of direction cosines along the Z-axis for use in R-Z DOT-IIW calculations.
4. Method of Solution: The ADOQ code 1) combines asymmetric quadrature data with symmetric quadrature data in one hemisphere of the unit S_n sphere 2) adjusts the level weights of the last asymmetric level to match the symmetric level, and 3) verifies the various relationships these data must satisfy.
5. Restrictions on the Complexity of the Problem: Up to 200 discrete directions may be input in the symmetric hemisphere data; up to 100 discrete directions may be input in the asymmetric portion of the asymmetric hemisphere; and up to 500 total, discrete directions may be computed. If these maximum values become limiting, only one DIMENSION statement in the FORTRAN program has to be consistently changed.

6. Typical Running Time: Seven, stacked cases required approximately 20 CPU seconds on the UNIVAC-1108 computer.

7. Unusual Features of the Program: The code performs quadrature data checks usually encountered in discrete ordinates transport codes. Running time is minimal.

8. Related and Auxiliary Programs: The DOQ[1] code may be used to generate the symmetric quadrature data. Output from the ADOQ code may be used in the DOT-IIW, two-dimensional, discrete ordinates transport code.

9. Status: The code is in production use at the Marshall Space Flight Center (MSFC). Users at MSFC load the code from a disk or tape with control cards followed by the user's input data.

10. References: 1. R. G. Soltesz, R. K. Disney, J. Jedruch, and S. L. Zeigler, WANL-PR(LL)-034, Volume 5, "Two-Dimensional, Discrete Ordinates Transport Techniques, August 1970.

11. Machine Requirements: The ADOQ code is in production at MSFC on the UNIVAC-1108 with 65 K core storage locations. The program requires only 15 K decimal locations. Only the standard, input, output, and punch disks are required.

12. Programming Language Used: The code is written in standard, USASI FORTRAN-IV.

13. Operating System or Monitor Under Which Program is Executed: The ADOQ code is operational under the EXEC8 Monitor System.

14. Other Programming or Operating Information or Restrictions: None

15. Name and Establishment of Authors:

R. K. Disney and R. G. Soltesz
Westinghouse Astronuclear Laboratory
P. O. Box 10864
Pittsburgh, Pa. 15236

B.2 INPUT DATA DESCRIPTION

Input data for the ADOQ code are prepared in either of two standard, FORTRAN formats. Integer data are input in a "right adjusted"* (I12) FORTRAN format; floating point (or real) data are input in a (6D12.5) FORTRAN format. The input instructions are described in Table B-1.

*"Right -adjusted" means that the last significant digit is at the extreme right of the field.

TABLE B-1

ADOQ COMPUTER CODE INPUT INSTRUCTIONS

Card	Variable	Format	Description
1	NAZ	3I12	Number of μ angles per η level in the asymmetric portion of the asymmetric hemisphere (Enter an even integer)
	NPL		Number of η levels in the asymmetric portion of the asymmetric hemisphere
	NDR		Enter a zero
2	NQ1	I12	Quadrature order in the asymmetric hemisphere (6, 8, 10, 12, . . . S_6, S_8, S_{10}, S_{12}, etc.)
3	AM	6D12.5*	Symmetric Discrete Ordinate Quadrature Direction Cosines, μ_m, NQ1*(NQ1 + 4)/2 values
4	AE	6D12.5	Symmetric Discrete Ordinate Quadrature Direction Cosines, η_m, NQ1*(NQ1 + 4)/2 values
5	AW	6D12.5	Symmetric Discrete Ordinate Quadrature Weights, W_m, NQ1*(NQ1 + 4)/2 values.
6	NQ2	I12	Quadrature order in the symmetric hemisphere (6, 8, 10, 12, ... S_6, S_8, S_{10}, S_{12}, etc.)
7	BM	6D12.5	Symmetric Discrete Ordinate Quadrature Direction Cosines, μ_m NQ2*(NQ2 + 4)/2 valued
8	BE	6D12.5	Symmetric Discrete Ordinate Quadrature Direction Cosines. η_m, NQ2*(NQ2 + 4)/2 values
9	BW	6D12.5	Symmetric Discrete Ordinate Quadrature Weights, W_m, NQ2*(NQ2 + 4)/2 values
10	XE	6D12.5	Asymmetric Quadrature Direction Cosines, η_m, within the first symmetric quadrature direction cosine level (NPL values) in the asymmetric hemisphere
11	XW	6D12.5	Asymmetric Quadrature Weights, W_m, within the first symmetric quadrature direction cosing level (NPL values) in the asymmetric hemisphere

* If quadrature data are punched in a FORTRAN (6F12.9) format, as provided by the DOQ code, the data are compatible with the ADOQ input requirements.

TABLE B-1
(Continued)

ADOQ COMPUTER CODE INPUT INSTRUCTIONS

Card	Variable	Format	Description
12	XA	6D12.5	Location, in degrees, of the angles within the η level. XA entries must be between 180.0 and 0.0 degrees (NAZ values)
13	DXA	6D12.5	Angular width, in degrees, of the angles within the level. The DXA entries must sum to 180.0 (NAZ values)

This concludes the required input data for one calculation; stacked cases may be input starting with card 1. All input data are required for each case.

B.3 PROBLEM SETUP INFORMATION

B.3.1 Tape Assignments

The ADOQ code uses only three tapes (or disks). These are:

Tape 5 – Input Data

Tape 6 – Printed Output

Tape 7 – Punched Output

No scratch tapes or data tapes are required.

B.3.2 Running Time

The ADOQ code requires very little computer time. As an example, seven stacked cases of input data were input to the ADOQ code. The total number of space angles per set ranged from 80 to 146 angles. The resulting 14 sets of quadrature data were obtained in 21.0 Central Processor Unit (CPU) seconds on the MSFC UNIVAC-1108 computer. Compile time was also included in the 21 seconds. Approximately 900 punched cards of quadrature data were obtained from this calculation.

B.3.3 Error Messages

Because of the simplicity of the code and the input data requirements, no programmed error messages were included. The user may encounter UNIVAC-1108 System error messages, however. One of the more frequent messages is "The Interpretation of Meaningless Input Was Attempted."

This message usually implies the input data are out of order, or of the improper number required.

B.3.4 Limitations

Fixed dimensions have been assigned to the dimensional variables in the ADOQ code. The limitations are as follows:

Maximum Number of Values	Variable
200	AM, AE,AW, BM, BE, BW
100	XE, XW, XA, DXA
500	DM, DE, DW (These variables are output data and include both hemispheres)

If these maximum values become limiting, only one DIMENSION statement in the FORTRAN program has to be consistently changed to alleviate the limitation.

The routine checks printed with each quadrature data calculation provide some indication of the accuracy or precision of the ADOQ code calculation.

B.3.5 Sample Problem Input

A typical sample problem input listing is given in Table B-2 to assist the user in preparing the input data. The actual computer printout from this calculation is included in Section B.4.1.

B.4 DESCRIPTION OF OUTPUT

B.4.1 Printed Output

Printed output from the sample problem given in Section B.3.5 is given in Table B-3. The first set of quantitites printed out are the NPL input values of XE and XW, and the respective polar angle limits in degrees and radians. The second set of quantities printed out are the quadrature checks described in Section B.6 for each hemisphere. The final values of μ, η, and W are listed next. The values are listed in column form in the order that they are punched on cards. The code then reverses the geometry 180 degrees and repeats the calculation. The quadrature checks and the quadrature data in the inverted geometry are then printed out. If only one case of input data was provided, the calculation would then terminate at this point.

B.4.2 Punched Output

Punched output from the ADOQ code consists of the following:

1. A 7U card with a 7 punched in Column 2 and a U punched in Column 3,
2. The direction cosines, μ_m, in an (6F12.9) FORTRAN format,
3. The direction cosines, η_m, in an (6F12.9) FORTRAN format,
4. A T card with a T punched in Column 3,

TABLE B-2

SAMPLE PROBLEM CARD INPUT

```
           6          11           0
          10
-2.26949E-01-1.48874E-01 1.48874E-01-5.01663E-01-4.33395E-01-1.48874E-01
 1.48874E-01 4.33395E-01-7.33759E-01-6.79410E-01-4.33395E-01-1.48874E-01
 1.48874E-01 4.33395E-01 6.79410E-01-9.01204E-01-8.65063E-01-6.79410E-01
-4.33395E-01-1.48874E-01 1.48874E-01 4.33395E-01 6.79410E-01 8.65063E-01
-9.88856E-01-9.73907E-01-8.65063E-01-6.79410E-01-4.33395E-01-1.48874E-01
 1.48874E-01 4.33395E-01 6.79410E-01 8.65063E-01 9.73907E-01-2.26949E-01
-1.48874E-01 1.48874E-01-5.01663E-01-4.33395E-01-1.48874E-01 1.48874E-01
 4.33395E-01-7.33759E-01-6.79410E-01-4.33395E-01-1.48874E-01 1.48874E-01
 4.33395E-01 6.79410E-01-9.01204E-01-8.65063E-01-6.79410E-01-4.33395E-01
-1.48874E-01 1.48874E-01 4.33395E-01 6.79410E-01 8.65063E-01-9.88856E-01
-9.73907E-01-8.65063E-01-6.79410E-01-4.33395E-01-1.48874E-01 1.48874E-01
 4.33395E-01 6.79410E-01 8.65063E-01 9.73907E-01
-9.73907E-01-9.73907E-01-9.73907E-01-8.65063E-01-8.65063E-01-8.65063E-01
-8.65063E-01-8.65063E-01-6.79410E-01-6.79410E-01-6.79410E-01-6.79410E-01
-6.79410E-01-6.79410E-01-6.79410E-01-4.33395E-01-4.33395E-01-4.33395E-01
-4.33395E-01-4.33395E-01-4.33395E-01-4.33395E-01-4.33395E-01-4.33395E-01
-1.48874E-01-1.48874E-01-1.48874E-01-1.48874E-01-1.48874E-01-1.48874E-01
-1.48874E-01-1.48874E-01-1.48874E-01-1.48874E-01-1.48874E-01 9.73907E-01
 9.73907E-01 9.73907E-01 8.65063E-01 8.65063E-01 8.65063E-01 8.65063E-01
 8.65063E-01 6.79410E-01 6.79410E-01 6.79410E-01 6.79410E-01 6.79410E-01
 6.79410E-01 6.79410E-01 4.33395E-01 4.33395E-01 4.33395E-01 4.33395E-01
 4.33395E-01 4.33395E-01 4.33395E-01 4.33395E-01 4.33395E-01 1.48874E-01
 1.48874E-01 1.48874E-01 1.48874E-01 1.48874E-01 1.48874E-01 1.48874E-01
 1.48874E-01 1.48874E-01 1.48874E-01 1.48874E-01
 0.          1.66678E-02 1.66678E-02 0.          2.44419E-02 1.29209E-02
 1.29209E-02 2.44419E-02 0.          2.70111E-02 8.54983E-03 1.92106E-02
 1.92106E-02 8.54983E-03 2.70111E-02 0.          2.44419E-02 8.54983E-03
 2.74683E-02 6.85661E-03 6.85661E-03 2.74683E-02 8.54983E-03 2.44419E-02
 0.          1.66678E-02 1.29209E-02 1.92106E-02 6.85661E-03 1.82251E-02
 1.82251E-02 6.85661E-03 1.92106E-02 1.29209E-02 1.66678E-02 0.
 1.66678E-02 1.66678E-02 0.          2.44419E-02 1.29209E-02 1.29209E-02
 2.44419E-02 0.          2.70111E-02 8.54983E-03 1.92106E-02 1.92106E-02
 8.54983E-03 2.70111E-02 0.          2.44419E-02 8.54983E-03 2.74683E-02
 6.85661E-03 6.85661E-03 2.74683E-02 8.54983E-03 2.44419E-02 0.
 1.66678E-02 1.29209E-02 1.92106E-02 6.85661E-03 1.82251E-02 1.82251E-02
 6.85661E-03 1.92106E-02 1.29209E-02 1.66678E-02
           6
-3.61249E-01-2.38619E-01 2.38619E-01-7.50201E-01-6.61209E-01-2.38619E-01
 2.38619E-01 6.61209E-01-9.71113E-01-9.32470E-01-6.61209E-01-2.38619E-01
 2.38619E-01 6.61209E-01 9.32470E-01-3.61249E-01-2.38619E-01 2.38619E-01
-7.50201E-01-6.61209E-01-2.38619E-01 2.38619E-01 6.61209E-01-9.71113E-01
-9.32470E-01-6.61209E-01-2.38619E-01 2.38619E-01 6.61209E-01 9.32470E-01
-9.32470E-01-9.32470E-01-9.32470E-01-6.61209E-01-6.61209E-01-6.61209E-01
-6.61209E-01-6.61209E-01-2.38619E-01-2.38619E-01-2.38619E-01-2.38619E-01
-2.38619E-01-2.38619E-01-2.38619E-01 9.32470E-01 9.32470E-01 9.32470E-01
 6.61209E-01 6.61209E-01 6.61209E-01 6.61209E-01 6.61209E-01 2.38619E-01
```

TABLE B-2 (Continued)

2.38619E-01	2.38619E-01	2.38619E-01	2.38619E-01	2.38619E-01	2.38619E-01	
0.	4.28311E-02	4.28311E-02	0.	5.52387E-02	3.49517E-02	
3.49517E-02	5.52387E-02	0.	4.28311E-02	3.49517E-02	3.91956E-02	
3.91956E-02	3.49517E-02	4.28311E-02	0.	4.28311E-02	4.28311E-02	
0.	5.52387E-02	3.49517E-02	3.49517E-02	5.52387E-02	0.	
4.28311E-02	3.49517E-02	3.91956E-02	3.91956E-02	3.49517E-02	4.28311E-02	
0.999689504	0.998364376	0.995981843	0.992543900	0.988054126	0.982517263	S96-ETA
0.975939174	0.968326828	0.959688291	0.950032718	0.939370340	0.927712457	S96-ETA
0.000796792	0.001853961	0.002910732	0.003964554	0.005014203	0.006058546	S96-WTS
0.007096471	0.008126877	0.009148671	0.010160770	0.011162102	0.012151605	S96-WTS
179.0	162.5	120.0	60.0	17.5	1.0	S-124
2.0	28.0	60.0	60.0	28.0	2.0	S-124

TABLE B-3

SAMPLE PROBLEM PRINTOUT

POLAR DATA

1	9.996895040000D-01	3.983960000000D-04	2.287383341017D+00	3.992237055600D-02
2	9.983643760000D-01	9.269805000000D-04	4.172710374730D+00	7.282753477115D-02
3	9.959818430000D-01	1.455366000000D-03	6.045531630238D+00	1.055144319811D-01
4	9.925439000000D-01	1.982277000000D-03	7.914785881049D+00	1.381390732146D-01
5	9.880541260000D-01	2.507101500000D-03	9.782527669138D+00	1.707373169938D-01
6	9.825172630000D-01	3.029273000000D-03	1.164948671941D+01	2.033218994209D-01
7	9.759391740000D-01	3.548235500000D-03	1.351598804678D+01	2.358984930764D-01
8	9.683268280000D-01	4.063438500000D-03	1.538219862991D+01	2.684700122877D-01
9	9.596882910000D-01	4.574335500000D-03	1.724821296868D+01	3.010381063985D-01
10	9.500327180000D-01	5.080385000000D-03	1.911408863114D+01	3.336037801313D-01
11	9.393703400000D-01	5.581051000000D-03	2.097986279882D+01	3.661676824560D-01

TABLE B-3 (Continued)

QUADRATURE CHECKS FOR ASYMMETRIC SET

SUM OF W0*S........	4.999995600000D-01
SUM OF W0*S*MU*S..	2.610548440765D-15
SUM OF W0*S*ETA*S.	-2.516425886356D-01
SUM OF W0*MU**2...	1.669495693624D-01

QUADRATURE CHECKS FOR SYMMETRIC SET

SUM OF W0*S........	4.999998000000D-01
SUM OF W0*S*MU*S..	6.310887241768D-30
SUM OF W0*S*ETA*S.	2.549733776804D-01
SUM OF W0*MU**2...	1.666665875157D-01

TABLE B-3 (Continued)

MODIFIED QUADRATURE DATA

NO.	MU	ETA	WEIGHT
1	-.024917777	-.999689504	0.000000000
2	-.024913982	-.999689504	.000004427
3	-.023764506	-.999689504	.000061973
4	-.012458888	-.999689504	.000132799
5	.012458888	-.999689504	.000132799
6	.023764506	-.999689504	.000061973
7	.024913982	-.999689504	.000004427
8	-.057171433	-.998364376	0.000000000
9	-.057162725	-.998364376	.000010300
10	-.054525365	-.998364376	.000144197
11	-.028585716	-.998364376	.000308993
12	.028585716	-.998364376	.000308993
13	.054525365	-.998364376	.000144197
14	.057162725	-.998364376	.000010300
15	-.089555393	-.995981843	0.000000000
16	-.089541753	-.995981843	.000016171
17	-.085410496	-.995981843	.000226390
18	-.044777696	-.995981843	.000485122
19	.044777696	-.995981843	.000485122
20	.085410496	-.995981843	.000226390
21	.089541753	-.995981843	.000016171
22	-.121887680	-.992543900	0.000000000
23	-.121869116	-.992543900	.000022025
24	-.116246347	-.992543900	.000308354
25	-.060943840	-.992543900	.000660759
26	.060943840	-.992543900	.000660759
27	.116246347	-.992543900	.000308354
28	.121869116	-.992543900	.000022025
29	-.154107249	-.988054126	0.000000000
30	-.154083777	-.988054126	.000027857
31	-.146974695	-.988054126	.000389994
32	-.077053624	-.988054126	.000835700
33	.077053624	-.988054126	.000835700
34	.146974695	-.988054126	.000389994
35	.154083777	-.988054126	.000027857
36	-.186171501	-.982517263	0.000000000
37	-.186143147	-.982517263	.000033659
38	-.177554917	-.982517263	.000471220
39	-.093085751	-.982517263	.001009758
40	.093085751	-.982517263	.001009758
41	.177554917	-.982517263	.000471220
42	.186143147	-.982517263	.000033659
43	-.218042951	-.975939174	0.000000000

TABLE B-3 (Continued)

44	-.218009742	-.975939174	.000039425
45	-.207951259	-.975939174	.000551948
46	-.109021476	-.975939174	.001182745
47	.109021476	-.975939174	.001182745
48	.207951259	-.975939174	.000551948
49	.218009742	-.975939174	.000039425
50	-.249686111	-.968326828	0.000000000
51	-.249648083	-.968326828	.000045149
52	-.238129877	-.968326828	.000632090
53	-.124843056	-.968326828	.001354479
54	.124843056	-.968326828	.001354479
55	.238129877	-.968326828	.000632090
56	.249648083	-.968326828	.000045149
57	-.281066512	-.959688291	0.000000000
58	-.281023704	-.959688291	.000050826
59	-.268057897	-.959688291	.000711563
60	-.140533256	-.959688291	.001524778
61	.140533256	-.959688291	.001524778
62	.268057897	-.959688291	.000711563
63	.281023704	-.959688291	.000050826
64	-.312150340	-.950032718	0.000000000
65	-.312102798	-.950032718	.000056449
66	-.297703070	-.950032718	.000790282
67	-.156075170	-.950032718	.001693462
68	.156075170	-.950032718	.001693462
69	.297703070	-.950032718	.000790282
70	.312102798	-.950032718	.000056449
71	-.342904308	-.939370340	0.000000000
72	-.342852082	-.939370340	.000064109
73	-.327033651	-.939370340	.000897526
74	-.171452154	-.939370340	.001923270
75	.171452154	-.939370340	.001923270
76	.327033651	-.939370340	.000897526
77	.342852082	-.939370340	.000064109
78	-.501663000	-.865063000	0.000000000
79	-.433395000	-.865063000	.024441900
80	-.148874000	-.865063000	.012920900
81	.148874000	-.865063000	.012920900
82	.433395000	-.865063000	.024441900
83	-.733759000	-.679410000	0.000000000
84	-.679410000	-.679410000	.027011100
85	-.433395000	-.679410000	.008549830
86	-.148874000	-.679410000	.019210600
87	.148874000	-.679410000	.019210600
88	.433395000	-.679410000	.008549830
89	.679410000	-.679410000	.027011100
90	-.901204000	-.433395000	0.000000000

TABLE B-3 (Continued)

91	-.865063000	-.433395000	.024441900
92	-.679410000	-.433395000	.008549830
93	-.433395000	-.433395000	.027468300
94	-.148874000	-.433395000	.006856610
95	.148874000	-.433395000	.006856610
96	.433395000	-.433395000	.027468300
97	.679410000	-.433395000	.008549830
98	.865063000	-.433395000	.024441900
99	-.988856000	-.148874000	0.000000000
100	-.973907000	-.148874000	.016667800
101	-.865063000	-.148874000	.012920900
102	-.679410000	-.148874000	.019210600
103	-.433395000	-.148874000	.006856610
104	-.148874000	-.148874000	.018225100
105	.148874000	-.148874000	.018225100
106	.433395000	-.148874000	.006856610
107	.679410000	-.148874000	.019210600
108	.865063000	-.148874000	.012920900
109	.973907000	-.148874000	.016667800
110	-.361249000	.932470000	0.000000000
111	-.238619000	.932470000	.042831100
112	.238619000	.932470000	.042831100
113	-.750201000	.661209000	0.000000000
114	-.661209000	.661209000	.055238700
115	-.238619000	.661209000	.034951700
116	.238619000	.661209000	.034951700
117	.661209000	.661209000	.055238700
118	-.971113000	.238619000	0.000000000
119	-.932470000	.238619000	.042831100
120	-.661209000	.238619000	.034951700
121	-.238619000	.238619000	.039195600
122	.238619000	.238619000	.039195600
123	.661209000	.238619000	.034951700
124	.932470000	.238619000	.042831100

TABLE B-3 (Continued)

```
QUADRATURE CHECKS FOR ASYMMETRIC SET

SUM OF W0*S........  4.999995600000D-01
SUM OF W0*S*MU*S..   2.610548440765D-15
SUM OF W0*S*ETA*S.   2.516425886356D-01
SUM OF W0*MU**2...   1.669495693624D-01

QUADRATURE CHECKS FOR SYMMETRIC SET

SUM OF W0*S........  4.999998000000D-01
SUM OF W0*S*MU*S..   6.310887241768D-30
SUM OF W0*S*ETA*S.  -2.549733776804D-01
SUM OF W0*MU**2...   1.666665875157D-01
```

TABLE B-3 (Continued)

MODIFIED QUADRATURE DATA

NO.	MU	ETA	WEIGHT
1	-.361249000	-.932470000	0.000000000
2	-.238619000	-.932470000	.042831100
3	.238619000	-.932470000	.042831100
4	-.750201000	-.661209000	0.000000000
5	-.661209000	-.661209000	.055238700
6	-.238619000	-.661209000	.034951700
7	.238619000	-.661209000	.034951700
8	.661209000	-.661209000	.055238700
9	-.971113000	-.238619000	0.000000000
10	-.932470000	-.238619000	.042831100
11	-.661209000	-.238619000	.034951700
12	-.238619000	-.238619000	.039195600
13	.238619000	-.238619000	.039195600
14	.661209000	-.238619000	.034951700
15	.932470000	-.238619000	.042831100
16	-.024917777	.999689504	0.000000000
17	-.024913982	.999689504	.000004427
18	-.023764506	.999689504	.000061973
19	-.012458888	.999689504	.000132799
20	.012458888	.999689504	.000132799
21	.023764506	.999689504	.000061973
22	.024913982	.999689504	.000004427
23	-.057171433	.998364376	0.000000000
24	-.057162725	.998364376	.000010300
25	-.054525365	.998364376	.000144197
26	-.028585716	.998364376	.000308993
27	.028585716	.998364376	.000308993
28	.054525365	.998364376	.000144197
29	.057162725	.998364376	.000010300
30	-.089555393	.995981843	0.000000000
31	-.089541753	.995981843	.000016171
32	-.085410496	.995981843	.000226390
33	-.044777696	.995981843	.000485122
34	.044777696	.995981843	.000485122
35	.085410496	.995981843	.000226390
36	.089541753	.995981843	.000016171
37	-.121887680	.992543900	0.000000000
38	-.121869116	.992543900	.000022025
39	-.116246347	.992543900	.000308354
40	-.060943840	.992543900	.000660759
41	.060943840	.992543900	.000660759
42	.116246347	.992543900	.000308354
43	.121869116	.992543900	.000022025

TABLE B-3 (Continued)

44	-.154107249	.988054126	0.000000000
45	-.154083777	.988054126	.000027857
46	-.146974695	.988054126	.000389994
47	-.077053624	.988054126	.000835700
48	.077053624	.988054126	.000835700
49	.146974695	.988054126	.000389994
50	.154083777	.988054126	.000027857
51	-.186171501	.982517263	0.000000000
52	-.186143147	.982517263	.000033659
53	-.177554917	.982517263	.000471220
54	-.093085751	.982517263	.001009758
55	.093085751	.982517263	.001009758
56	.177554917	.982517263	.000471220
57	.186143147	.982517263	.000033659
58	-.218042951	.975939174	0.000000000
59	-.218009742	.975939174	.000039425
60	-.207951259	.975939174	.000551948
61	-.109021476	.975939174	.001182745
62	.109021476	.975939174	.001182745
63	.207951259	.975939174	.000551948
64	.218009742	.975939174	.000039425
65	-.249686111	.968326828	0.000000000
66	-.249648083	.968326828	.000045149
67	-.238129877	.968326828	.000632090
68	-.124843056	.968326828	.001354479
69	.124843056	.968326828	.001354479
70	.238129877	.968326828	.000632090
71	.249648083	.968326828	.000045149
72	-.281066512	.959688291	0.000000000
73	-.281023704	.959688291	.000050826
74	-.268057897	.959688291	.000711563
75	-.140533256	.959688291	.001524778
76	.140533256	.959688291	.001524778
77	.268057897	.959688291	.000711563
78	.281023704	.959688291	.000050826
79	-.312150340	.950032718	0.000000000
80	-.312102798	.950032718	.000056449
81	-.297703070	.950032718	.000790282
82	-.156075170	.950032718	.001693462
83	.156075170	.950032718	.001693462
84	.297703070	.950032718	.000790282
85	.312102798	.950032718	.000056449
86	-.342904308	.939370340	0.000000000
87	-.342852082	.939370340	.000064109
88	-.327033651	.939370340	.000897526
89	-.171452154	.939370340	.001923270
90	.171452154	.939370340	.001923270

TABLE B-3 (Continued)

91	.327033651	.939370340	.000897526
92	.342852082	.939370340	.000064109
93	-.501663000	.865063000	0.000000000
94	-.433395000	.865063000	.024441900
95	-.148874000	.865063000	.012920900
96	.148874000	.865063000	.012920900
97	.433395000	.865063000	.024441900
98	-.733759000	.679410000	0.000000000
99	-.679410000	.679410000	.027011100
100	-.433395000	.679410000	.008549830
101	-.148874000	.679410000	.019210600
102	.148874000	.679410000	.019210600
103	.433395000	.679410000	.008549830
104	.679410000	.679410000	.027011100
105	-.901204000	.433395000	0.000000000
106	-.865063000	.433395000	.024441900
107	-.679410000	.433395000	.008549830
108	-.433395000	.433395000	.027468300
109	-.148874000	.433395000	.006856610
110	.148874000	.433395000	.006856610
111	.433395000	.433395000	.027468300
112	.679410000	.433395000	.008549830
113	.865063000	.433395000	.024441900
114	-.988856000	.148874000	0.000000000
115	-.973907000	.148874000	.016667800
116	-.865063000	.148874000	.012920900
117	-.679410000	.148874000	.019210600
118	-.433395000	.148874000	.006856610
119	-.148874000	.148874000	.018225100
120	.148874000	.148874000	.018225100
121	.433395000	.148874000	.006856610
122	.679410000	.148874000	.019210600
123	.865063000	.148874000	.012920900
124	.973907000	.148874000	.016667800

5. A 6U card

6. The corresponding weights, W_m, in an (6F12.9) FORTRAN format,

7. A T card.

The data are provided with the asymmetric hemisphere in the $-\eta$ - direction. Following these data, the calculation is repeated with the resulting punched output containing the asymmetric hemisphere data in the $+\eta$ - direction.

B.5 PROGRAM LOGIC

The ADOQ code consists of a main program of approximately 180 FORTRAN cards and no subroutines. The calculational procedure is straightforward as follows:

1. All of the input data are read into core,
2. The polar angle limits of the asymmetric data are calculated,
3. The discrete direction data in the asymmetric region are calculated,
4. The initialization directions in the asymmetric region are calculated,
5. The last interval weight of the asymmetric region is adjusted to match the symmetric region data,
6. The azimuthal direction data in the asymmetric region are calculated,
7. The weights in the asymmetric region are calculated,
8. The opposite hemisphere, symmetric data are placed in the output data arrays,
9. Quadrature consistency checks are made in each hemisphere,
10. The final quadrature data are punched on cards and printed, and
11. The calculation is repeated, reversing the geometry 180°, starting with item 2 above.

B.6 METHOD OF SOLUTION

An angular flux, as computed by the DOT code, has a μ_m, η_m, and W_m associated with it such that:

(1) $$\mu_m^2 + \eta_m^2 + \xi_m^2 = 1.0$$

The weight, W_m, represents the fractional area on the unit sphere such that:

(2) $$\sum_M W_m = 1.0$$

In the ADOQ code, the area between η_U and η_L as shown in Figure B-1 is asymmetrically divided into NPL areas with respect to the η-axis. Each η-level is then subdivided into NAZ areas with respect to the μ-axis. An S_{96} Gaussian Quadrature,(3,4) for example, could be specified for the area between η_U and η_L. The remainder of the hemisphere could be specified with an S_{10} Gaussian Quadrature. The opposite hemisphere could contain any desired symmetric quadrature data.

In matching the last level asymmetric data, η_L, with the symmetric data, the weight of the last asymmetric level, W_L^A, is adjusted such that:

$$W_L^A = W_L^A + W_1^S - \sum_{l=1}^{L-1} W_l^A \tag{3}$$

Where W_L^A are the input parameters, XW. The code then proportions the individual level weights within the asymmetric portion of the hemisphere by the equation:

$$W_m^A = W_l^A \cdot \Delta\theta_m \tag{4}$$

Where $\Delta\theta_m$ are the input parameters, DXA.

The ADOQ code first computes and punches on cards the complete quadrature data for input to the DOT-IIW code and then rotates the geometry 180 degrees and repeats the computations.

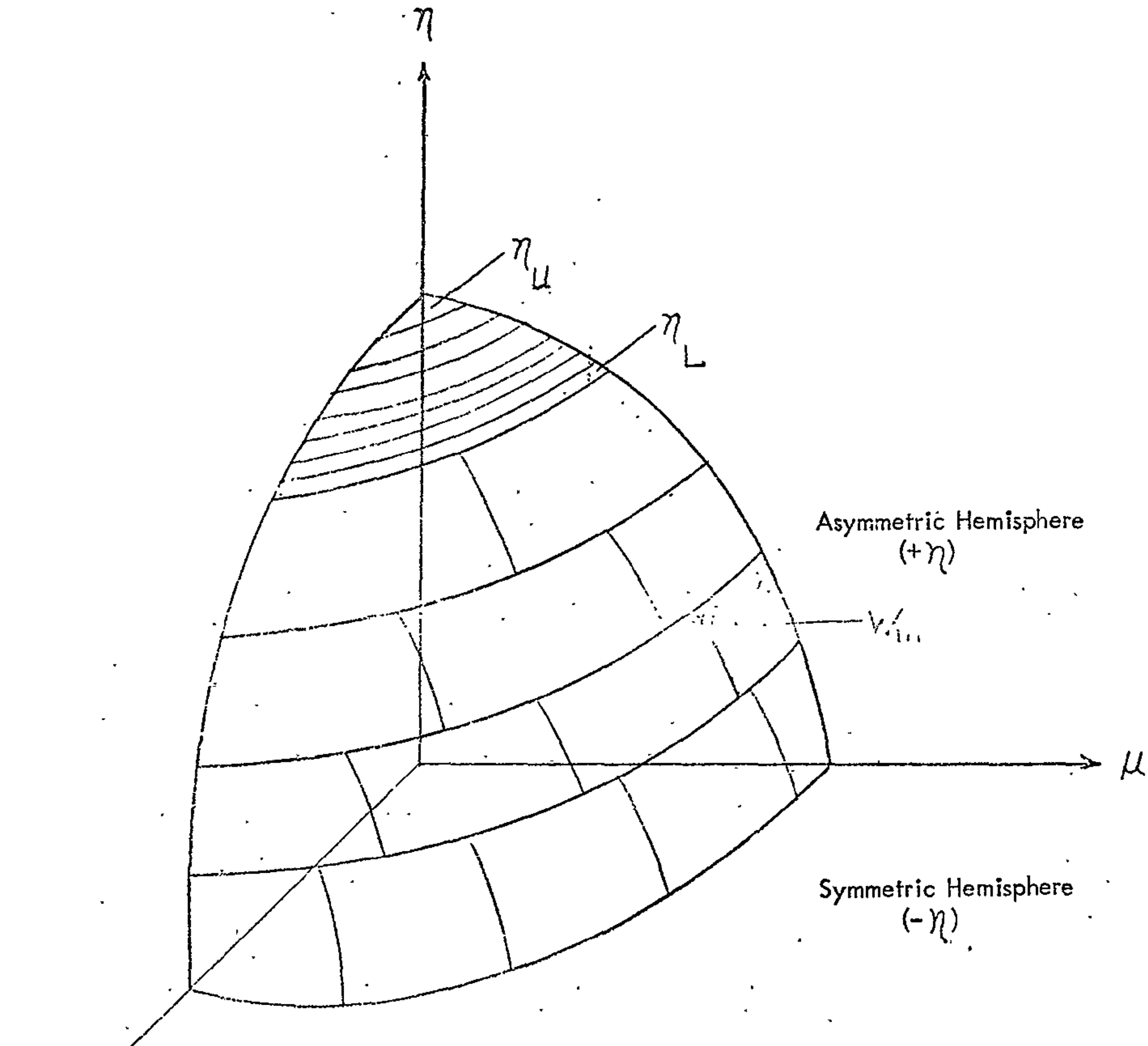
The final computation performed by the ADOQ code consists of computing:

$$SW = \sum_M W_m \tag{5}$$

SW should approach 0.5 in each hemisphere.

$$SM = \sum_M \mu_m \tag{6}$$

SM should approach 0.0 in each hemisphere.



Note: 1. One octant of the unit sphere is shown.

2. The areas on the sphere are illustrated as rectangles, but are really contiguous areas of varied form.

Figure B-1. ADOQ Geometry

(7) $$SE = \sum_{M} \eta_m$$

SE in the $= +\eta$ – hemisphere should be equal to SE in the $-\eta$ – hemisphere.

(8) $$SJ = \sum_{M} W_m \mu_m^2.$$

SJ should approach 1/6 in each hemisphere. This concludes the computations performed by the ADOQ code.

B.7 REFERENCES

1. K. D. Lathrop, "Ray Effects in Discrete Ordinates Equations," Nuclear Science and Engineering, Vol. 32, 357 - 369 (1968).

2. F. R. Mynatt, "Development of Two-Dimensional Discrete Ordinates Transport Theory for Radiation Shielding," Ph. D. Thesis, University of Tennessee, 1969.

3. M. Abramowitz and I. A. Stegun, Handbook of Mathematical Functions, NBS Applied Mathematics Series-55, USGPO, June 1964.

4. P. Davis and P. Rabinowitz, "Abscissas and Weights for Gaussian Quadratures of High Order," J. Research NBS-56, 34-37, RP2645, 1956.

APPENDIX C

"CODE DESCRIPTION AND USERS MANUAL FOR THE MAP RADIATION TRANSPORT COMPUTER CODE"*

* Originally published as document WANL-TME-2706

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COMPUTER CODE SYNOPSIS

1. Name: MAP[1] (Multigroup Angular Flux Program)
2. Computer: The code is operational on the following three, computer systems:
   1. CDC 6600, at Westinghouse Telecomputer Center with the Scope 3.2 Monitor System
   2. IBM 360/75, at Westinghouse Telecomputer Center with Release 18 of the IBM 360 Monitor System
   3. UNIVAC 1108, at MSFC with the EXEC 8 Monitor System
3. Nature of Physical Problem Solved: MAP solves for the last flight radiation transport in an r, z, θ geometry. The MAP code solves for the nuclear radiation transport to a detector surface from an energy-and angular-dependent surface source defined by the surface leakage data of a DOT-IIW[2] (or DOT)[3] discrete ordinate transport solution in r, z geometry. During the numerical integation over the surface source, the radiation transport can be through a void or, at option, radiation transport through a three-dimensional geometry described by intersecting quadratic surfaces can be solved. Uncollided energy-and angular-dependent, neutron or photon flux results at a detector plane are provided with the optional use of buildup factor techniques to estimate multiple scattering of photons available. Cross section data for use in the radiation transport can be obtained from 1) internal calculations of point value data from Klein-Nishina relationships and tables for photons, or 2) input values of macroscopic cross sections for materials in zones. General discrete ordinate quadrature data can be used as surface source input with two techniques available to calculate the angular-dependent source data from discrete ordinate data.
4. Method of Solution: A variable-interval numerical integration technique is used to integrate the visible surface angular leakage flux at each detector point. Energy dependence is treated as the multigroup data supplied to the code. The code is applicable to neutron, photon, or coupled neutron-photon analysis; the numerical integration accuracy is dependent upon the input discrete ordinate data.

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5. Restrictions on the Complexity of the Problem: The MAP code uses complete, flexible dimensioning to facilitate dynamic core storage allocation at execution time and during various phases of the calculation. Because of the use of a flexible dimensioning technique for each array, during a specific phase of the calculation, no size restriction is imposed for a given array. The only restriction is the size of the sum of all array storage required during a specific phase of the calculation. The required storage size for a given problem may be exactly computed as indicated in the documentation. In using the code on the CDC 6600, the total amount of core storage for a given problem may be specified at execution time. For the IBM 360/75 and UNIVAC 1108 computers, the size of BLANK COMMON must be compiled with a fixed dimension in the main subroutine.

6. Typical Running Time: Running time requirements for the CDC-6600 version of the MAP code can be approximated by the following relationship:

$$t \text{ (seconds CPU)} = \frac{\text{no. of source-to-detector point calculations}}{\text{250 to 600 calculations/second}}$$

7. Unusual Features of the Code: The code employs the r, z geometry discrete ordinate transport leakage angular flux data from the DOT-IIW (or DOT) code to calculate neutron and photon transport in a void or in a purely attenuating geometry to provide energy and angular dependent data at a detector surface. The coupling of DOT-IIW calculations through voids is handled by the MAP code.

8. Related and Auxiliary Codes: Photon absorption cross sections may be supplied by a GAMLEG-W[4] library tape. Discrete ordinate transport angular leakage flux data are supplied by the DOT-IIW (or DOT) code as the scalar flux output tape.

9. Status: The code is in production use at WANL on a CDC 6600 computer with additional development being devoted to increase the codes usefulness. Users at WANL load the code from disk or tape with control cards supplied by the user.

10. References:
1. R. K. Disney, R. G. Soltesz, S. L. Zeigler, J. Jedruch, WANL-TME-2706, "Code Description and User's Manual for the MAP Radiation Transport Computer Code," August 1970.

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2. R. G. Soltesz, R. K. Disney, and G. Collier, WANL-TME-1982, "User's Manual for the DOT-IIW Discrete Ordinates Transport Computer Code", December 1969.

3. F. R. Mynatt, F. J. Muckenthaler, and P. N. Stevens, CTC-INF-952, "Development of Two-Dimensional Discrete Ordinates Transport Theory for Radiation Shielding", August 1969.

4. R. G. Soltesz, R. K. Disney, and S. L. Zeigler, WANL-PR(LL)-034, Volume 3, "Cross Section Generation and Data Processing Techniques", August 1970.

11. Machine Requirements: The MAP code is in production at WANL on 65K and 131K CDC 6600 computers. The source program requires 22K decimal locations; the remaining locations are used for problem data storage. Up to six tape or disk devices are required in addition to input output, and punch disks.

12. Programming Language Used: The MAP code is written in standard USASI FORTRAN-IV. With minor change the code can be used on the CDC 6600, IBM 360/75, or UNIVAC 1108 computers.

13. Operating System or Monitor Under Which Program is Executed: The MAP code is operational under the CDC 6600 SCOPE 3.2 Monitor System, the IBM 360/75 Release 18 Monitor System and the UNIVAC 1108 EXEC8 Monitor System.

14. Other Programming or Operating Information or Restrictions: None.

15. Name and Establishment of Authors:

R. K. Disney, R. G. Soltesz, J. Jedruch and S. L. Zeigler
Westinghouse Astronuclear Laboratory
P.O. Box 10864
Pittsburgh, Pa. 15236

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1.0 INTRODUCTION

The MAP code is a radiation transport code employing point kernel techniques with a mulitgroup angular dependent surface source. The surface source geometry is the cylindrical surface defined by a DOT-IIW[1] (or DOT-II)[2] discrete ordinate transport code problem. Angular-and energy-dependent surface source data are obtained from the DOT-IIW (or DOT) code on magnetic tape and processed by the MAP code to provide flux and response data at a surface detector. The capability of the code includes:

- Two techniques of treating symmetric quadrature, discrete ordinate transport angular-dependent, leakage fluxes to provide a continuous variation of flux with angle.
- Techniques to use generalized quadrature, discrete ordinate transport, angular-dependent leakage fluxes (including asymmetric sets) at both the source surface and detector surface,
- Techniques to produce magnetic data tapes of angular-dependent flux data for use as boundary source input into subsequent discrete ordinate transport problems, and
- Techniques to calculate the uncollided radiation and estimates of collided radiation (using point kernel techniques) reaching detector surfaces in a geometry described by intersecting quadratic surfaces.

In addition to the calculation capabilities provided in the MAP code, the use of complete flexible dimensioning and the input data capability of the FIDO subroutine used in ANISN-W, DOT-IIW, and SCAP provides a code which is flexible and easy to use. The MAP code, with the capabilities described above, is an integral part of an automated, radiation transport, calculation capability which uses discrete ordinate transport techniques as an integral part of an overall radiation analysis procedure. The linkage of MAP to other analysis procedures by magnetic tape or punched data cards is illustrated in Figure 1-1. MAP provides techniques which circumvent the use of discrete ordinate transport codes in calculating radiation transport through voids or near-voids. MAP provides accurate results

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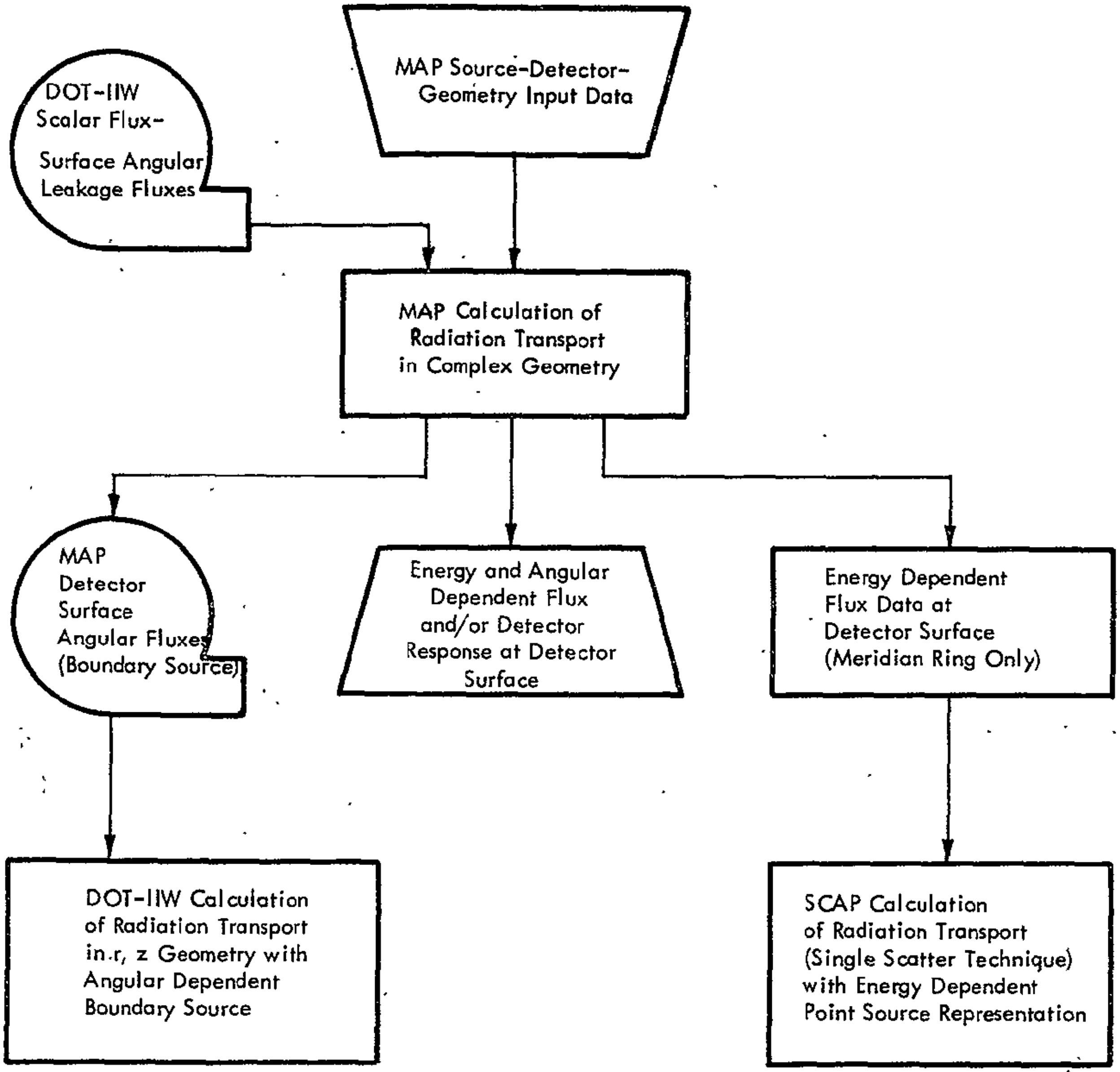

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Figure 1-1. MAP Code Linkages (Input and Output) To Other Radiation Transport Methods

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in areas where "ray effects"(Reference 3) due to discrete direction angular flux solutions produce anamalous results and provides for extended use of the discrete ordinate transport technique. MAP provides this capability without using high orders of angular quadrature or conventional symmetric quadrature techniques in discrete ordinate transport codes.

The logic used in performing the geometry-, angular-, and energy-dependent calculations is described in Section 2.0. Input data requirements for the use of the MAP code are described in Section 3.0; detailed user information describing the input is contained in Section 4.0. A description of the job setup for the CDC 6600 version of the MAP code, and a sample problem input (including a listing of the DOT-IIW input data deck used to generate the MAP input magnetic tape required for the sample problem) is described in Section 5.0. A description of the sample problem printed output obtained from a MAP problem, and the use of the input parameters to control the detail of the output data is described in Section 6.0. Section 7.0 describes the numerical procedures used in the MAP code including the use of the angular dependent, discrete ordinate transport, surface leakage data.

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2.0 CODE LOGIC

The general code logic used in the principal MAP calculations is presented in this section. Extensive use of flexible dimensioning throughout the MAP code provides for the sequential use of the same computer core memory locations (i.e., sequential use of blank COMMON storage) to maximize the code capability with a minimum computer memory core size.

Table 2-1 briefly defines the principal function of each subroutine in the MAP code and is presented to familiarize the user with the overall capability of the MAP code.

2.1 Calculational Procedure

Figure 2-1 illustrates the overall code logic of the MAP code. At entry point A and logic Step 1, the MAP code data setup is initialized by the input of data sets 1 and 2 described in Section 3.0. The next step performed is the setup of starting locations and maximum size of each input or calculated data array for each phase of the calculation. All data arrays are stored in BLANK COMMON using flexible dimensioning. The third step is the input of data set 3 using the FIDO generalized input subroutine. Errors in input data (e.g., wrong number of pieces data) are noted by the FIDO routine; if input errors are encountered, the problem is terminated. The fourth step in MAP is the control of various phases of the calculation logic. The five principal calculation steps in each operation are contained in five seperate subroutines. A brief description of each principal subroutine is discussed in later paragraphs. Control of the calculation logic is shown in Figure 2-1. The calculation subroutines are called in the order of GEOM1, GEOM2, GEOM3 (optional depending upon MAP input as described in Section 3.0), DOT, and RESP. Entry into each of these calculation subroutines reallocates the COMMON data storage to maximize the code flexibility. COMMON data storage as well as magnetic tape or disk file devices are used to link the various calculation subroutines.

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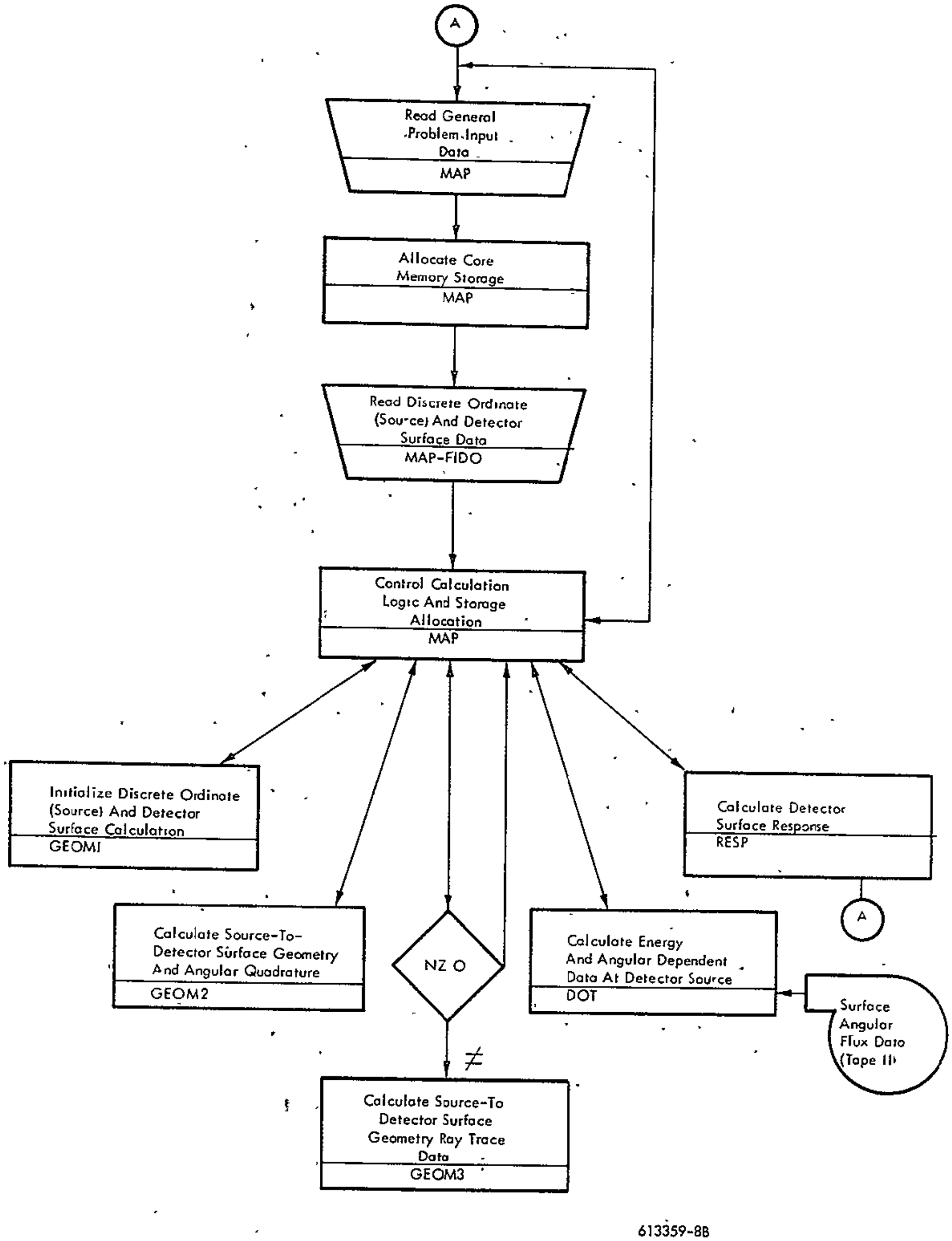

Figure 2-1. MAP Code Logic

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TABLE 2-1

DESCRIPTION OF MAP CODE SUBROUTINES

Subroutine Name	Principal Function
MAP II	Reads problem specifications data, allocates core memory storage, reads source and detector surface data.
GEOM1	Initializes geometry dependent source surface-detector surface calculation
GEOM2	Calculates the geometry dependent source surface-detector surface data
DOT	Calculates the energy and angular dependent detector response
RESP	Calculates detector response data
SCOUT	Prints two-dimensional floating point data arrays
QUAD	Calculates discrete ordinate angular quadrature related data
LAG	Calculates Lagrangian interpolating coefficients and Legendre polynomials
FIDO	Generalized input data read routine
DUMP	Routine used to dump portions of blank common storage
GEOM3	Reads complex geometry. Performs complex geometry ray trace for each surface source point and detector point by energy group.
AMBIG	Calculates the ambiguity indices of zone boundaries, i. e., the boundary surface relationship with the zone in the geometry described by intersecting quadratic surface.

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TABLE 2-1 (Continued)

DESCRIPTION OF MAP CODE SUBROUTINES

Subroutine Name	Principal Function
RAY	Performs line-of-sight ray trace through complex geometry described by intersecting quadratic surfaces.
GAMX	Calculates the photon absorption and scattering cross sections at energy points from library tape.
SIGK	Calculates the photon scattering cross section at a photon energy using Klein-Nishina equations for inelastic scattering of a photon with a free electron.
BUILD	Calculates the multiple-scatter buildup factor based on the cubic polynomial approximation.
AL	Performs an interpolation of data assuming a linear variation in the logarithm of the dependent and independent data.
WOT8	Prints up to 8 one-dimensional, mixed, fixed-floating point data arrays of variable length.
WIT	Prints two- or three-dimensional, fixed point data arrays.
WOT	Prints two- or three-dimensional, floating point data arrays.

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2.2 Description of Principal Subroutines

Calculations performed in each of the principal subroutines and/or subroutines used by these are described in the following paragraphs.

GEOM1 - performs the initial calculations on input data sets to provide data for subsequent calculations.

A series of input data consistency checks are performed. The calculations performed are the definition of the source surface and detector surface data including the radial and axial mesh coordinates at both surfaces. Subroutine QUAD calculates the discrete ordinate angular quadrature related data for later use in defining the angular-dependent source.

GEOM2 - calculates the energy-independent source surface-to-detector surface data for each source point and detector point. The top or bottom and side surfaces are calculated separately. The data for each detector point are placed on magnetic tape or disk file. If the top, bottom, or side surface is not visible to a detector, no tape or disk record is written for subsequent use in subroutine DOT. A detailed description of the calculation logic of GEOM2 is given in Section 7.0.

GEOM3 - an optional calculation step. This subroutine performs a last-flight transport calculation based on the use of point kernel techniques and the energy-and angular-dependent leakage flux. The logic is similar to GEOM2 except that the energy-dependent depth penetration for each source point-to-detector point is calculated. This energy-dependent data (in units of mean free paths of material penetration) are stored on magnetic tape or disk file for subsequent use in subroutine DOT. Detailed descriptions of this subroutine logic are presented in Section 7.0.

DOT - performs the calculations to provide energy-and angular-dependent data at the detector points on the detector surface. Geometry related data on magnetic tape or disk file (which were calculated in subroutine GEOM2 and GEOM3) are combined with

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the discrete ordinate angular leakage flux data from DOT-IIW (or DOT-II) to provide the desired results. These energy-and angular-dependent data are placed on magnetic tape or disk file at user option for use in subsequent DOT-IIW problems.

The scalar flux data the detector surface are placed on magnetic tape for use in the calculation of detector response data in subroutine RESP.

RESP - the last logical step in the MAP calculation logic. Calculations performed are the detector response for each set of input energy-dependent response data. Calculation of the detector response for each of the portions of the visible source surface is also performed.

At the completion of the RESP subroutine calculation, code control is returned to the main subroutine MAP as shown in Figure 2-1 to read a new set of input data.

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3.0 INPUT DATA DESCRIPTION

3.1 INPUT FORMAT

The input data for the MAP code are divided into the following four data sets:

1) Overall problem storage allocation,
2) Overall problem title and parameters,
3) Discrete ordinate transport, detector, and source data, and
4) Ray tracing geometry data.

The first data set is entered on a single formatted card which is the first physical card of each problem deck. The second data set consists of the title card and five cards of integer data on formatted cards in data fields of 12 columns each. This set of data is always required as input to a MAP problem and must be entered in the correct field of each card since a fixed FORTRAN format is used.

All remaining input data sets (3 and 4) of a MAP problem are written in one of three possible FORTRAN type formats. The integer data arrays (denoted by a dollar sign) must always be input in the standard MAP (FIDO)* format capability which consists of six fields of 12 columns in each field. Each field in the standard format is subdivided into three subfields as shown in Figure 3-1. Integer data must be entered as right adjusted** in the third subfield of each data field. Real data (denoted by a *, U, or V) may be entered in the standard MAP or one of two non-standard FORTRAN format capabilities.

The non-standard WANL MAP input formats which are shown in Figure 3-1 are included for user convenience and can only be used for any real (floating point) data array. These non-standard formats cannot include any operation type (fill, skip, interpolate, repeat, etc.), but can include blank fields on a card that cause the input routine to ignore the rest of the card; i.e., if the punched cross section data for a material includes 117 entries

*FIDO is a generalized input routine capable of performing operations to prepare data arrays. This routine is standardized through the DOT-IIW, ANISN-W, and MAP codes. The FIDO subroutine was developed by W. W. Engle, Jr., of Union Carbine Corporation Nuclear Division, (Computer Technology Center), Oak Ridge, Tennessee.

**"right adjusted" means that the least significant digit of an integer number is at the extreme right of the field.

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(9 groups by 13 table positions), the set would be 19 full cards and a final card of three entries using the U format. MAP, using this non-standard capability, would skip the last three fields and commence reading at the first data field of the next card.

In the standard MAP format, the second subfield may include one of the data type or operation type code letters.

The following characters may be entered:

$, *, U, V, R, I, T, S, F, A, +, -, Z, E, Q, N, M, W, X, or H.

$ indicates the beginning of an integer (fixed point) array. The first subfield identifies the array.

* indicates the beginning of a real (floating point) array. The first subfield identifies the array.

U indicates the beginning of a real (floating point) array in the non-standard format 6E12.5 and the data array beginning on the next physical card. The first subfield identifies the array.

V indicates the beginning of a real (floating point) array in the non-standard format 4 (1X, E16.9, 1X). The first subfield identifies the array beginning on the next physical card.

R indicates that the data contained in the third subfield are to be entered R times in succession. The first subfield defines the number of total successive entries or Repeats (e.g., a 16R 1.0 enters 16 1.0's).

I indicates linear Interpolation between the data in the associated third subfield and the following third subfield. The first subfield defines the number of interpolations between the two data entries (e.g., 4I 0.0, 10.0 enters 0.0, 2.0, 4.0, 6.0, 8.0, 10.0).

T indicates Termination of data reading for a particular subset of data. No further data reading for a subset of data is attempted and the program proceeds to the next subset and the next physical data card.

S indicates Skip. The first subfield defines the number of entries to be skipped. The third subfield may contain the first entry following the skips (e.g., 15S 1 enters a 1 in the 16th word of an array).

F indicates that the remainder of the present array is to be Filled with the data entry in the third subfield. Any entry in the first subfield is ignored (e.g., F 1.0 will enter a 1.0 for all entries in an array).

A indicates Address modification. The next non-blank data entry is entered in the Nth location of the present array where N is an integer entry in the third subfield associated with the A. Any entry in the first subfield is ignored. C-19

+ or − indicates exponentiation. The data entry in the third subfield is multiplied by 10^{+N} where N is the entry in the first subfield. This option allows more significant digits if necessary.

Z indicates the entry of Zeros. The integer entry in the first plus the third subfield indicates the number of successive zeros to be entered. (e.g., 10Z enters 10 zeros, Z 20 enters twenty zeros, and 10Z 20 enters 30 zeros).

E indicates End array. This option skips to the end of an array without the need for specifying the number of skips.

Q indicates sequence repeat. The integer entry in the first plus the third subfield indicates the number of previous entries to be repeated.

N indicates inverted sequence repeat. This option is similar to the Q option except that the previous entries are repeated in reverse order, (e.g., 0, 2, 4, 2N enters 0, 2, 4, 4, 2).

M indicates inverted sequence repeat except that the signs of previous entries are reverse when they are repeated.

W indicates the array identified by the first subfield will be read according to the format on the following card.

X indicates the array identified by the first subfield will be read according to the last variable format read in. For example,

3W	Card 1 (remainder of card must be blank)
(7E 10.3)	Card 2 (contains format only)
3X	Card 3 (remainder of card must be blank)
	Card 4 through N (containthe data according to the specified format. No blank fields are allowed).

H indicates the beginning of an alphanumeric descriptive title card array. Each card input in this manner is a separate 72 column title card.

The following restrictions must be observed when writing input data for the MAP

1) Floating point zeros must be written as 0. or 0.0; A .0 or −0.0 in either the standard or non-standard format is not acceptable.

2) Blanks are ignored and the reading of data commences on the next physical card for the non-standard format and on the next field after the blank field for the standard formats.

3) If an I is specified in any data field, the next data field may not be either blank or an A entry.

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4) The third subfield of a data field containg a $ or a * may contain any integer, N. The next data entry is assumed to be the (N + 1) th member of the array. Normally this third subfield is blank and is interpreted as zero.

Integer data in the third subfield must be right adjusted. Floating point data may be written with or without an exponent and with or without a decimal point. If the decimal point is not included, it is assumed to be immediately to the left of the exponent field within the none -column subfield. If there is no exponent, the decimal point is assumed to be at the extreme right of the nine column subfield.

3.2 INPUT DATA INSTRUCTIONS

This section describes the problem input data for the MAP code. Other sections present a more detailed description of the data presented here. The quantity in slashes represents the array dimension, or the number of pieces of data required, and the expression in braces is the condition requiring that array or set of arrays. Arrays or sets of arrays with the corresponding terminate (T) card which are not required should not be entered. If no condition is specified, the array is required. Note that a T card must follow the data entered in data sets 3 and 4: no T card is entered after data sets 1 and 2.

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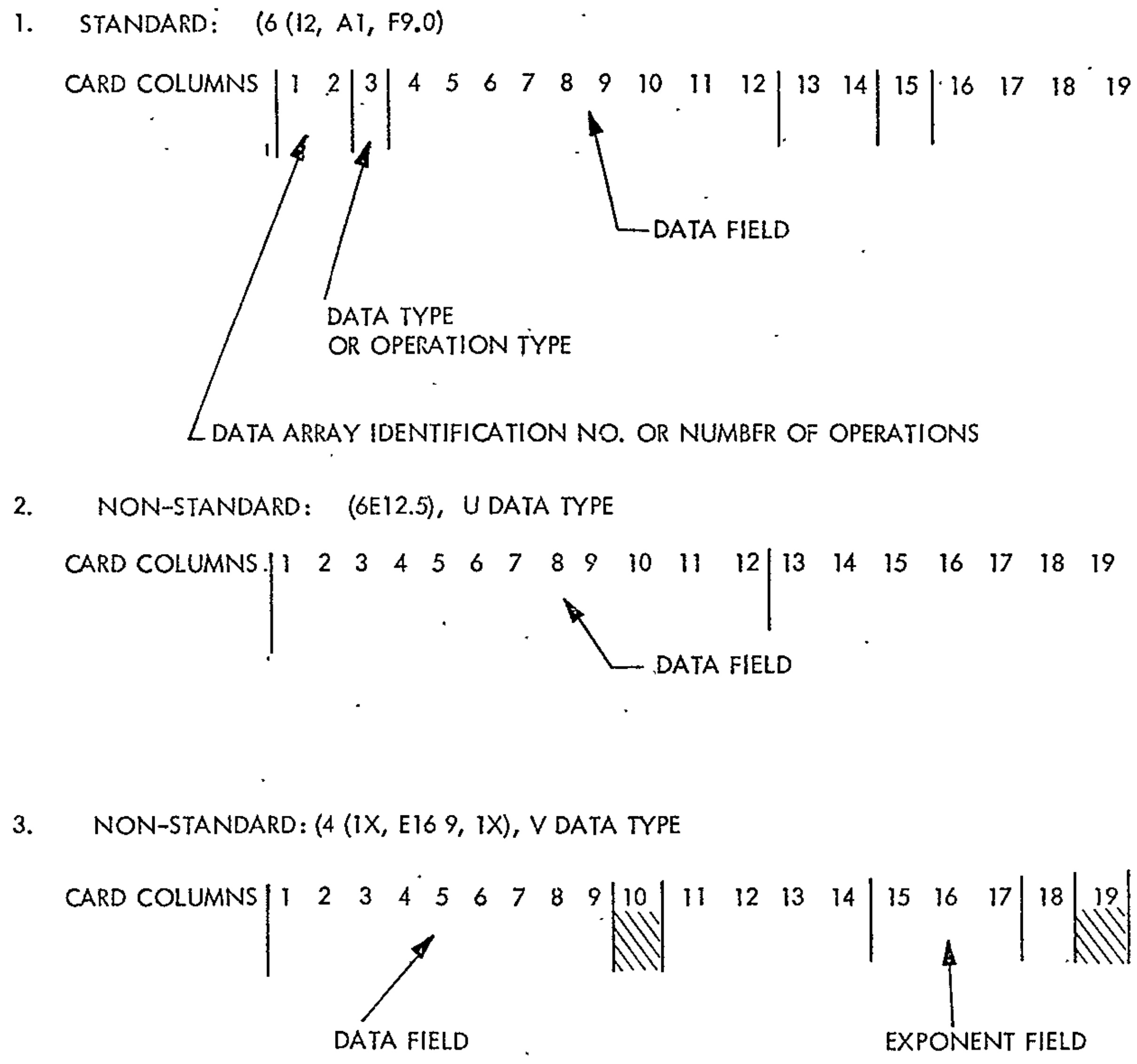

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Figure 3-1. MAP (FIDO) Input Formats

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DATA SET 1 - OVERALL PROBLEM CORE MEMORY STORAGE ALLOCATION

Card	Format	Column	Variable	Description
1	I12	1 - 12	ISIZE	The number of core memory storage locations to be allocated for MAP problem data storage. On the Westinghouse CDC 6600 the value of ISIZE can be assigned as follows:

Job Field Length	ISTZE
$150,000_8$	$30,000_{10}$
$250,000_8$	$62,000_{10}$
$350,000_8$	$94,000_{10}$

On a computer with a fixed COMMON size requirement, ISIZE is set by the size of the MAP COMMON size.

DATA SET 2 - OVERALL PROBLEM TITLE AND PROBLEM DATA (OPTIONS, CONTROL, and SIZE SPECIFICATION)

Card	Format	Column	Variable	Description
2	12A6	1 - 72	TITLE	Problem description title
3	6I12	-----	-----	Source Surface Specifications
		1 - 12	NRI	Number of radial mesh intervals in the discrete ordinate transport problem (DOT-IIW or DOT problem).
		13 - 24	NRK	Number of radial mesh intervals in the source surface integration. NRK specifies equal size intervals (equal ΔR). If NRK equal to 0, then the DOT-IIW radial mesh intervals are used in the integration.
		25 - 36	NZI	Number of axial mesh intervals in the discrete ordinate transport problem (DOT-IIW or DOT problem).
		37 - 48	NZK	Number of axial mesh intervals in the source surface integration. NZK specifies equal size intervals (equal ΔZ). If NZK equal to 0, then the DOT-IIW axial mesh intervals are used in the integration.
		49 - 60	NMU	Number of azimuthal mesh intervals in the source surface integration on the top or bottom surface. NMU intervals are used in the 0° - 180° range.
		61 - 72	NMUS	Number of azimuthal mesh intervals in the source surface integration on the side surface. NMUS intervals are used in the 0° to θ° range where θ is determined from the visible side surface.

DATA SET 2 (CONTINUED)

Card	Format	Column	Variable	Description
4	6I12	-----	-----	Multigroup Angular Flux Parameters
		1 - 12	NGN	Number of energy groups in problem. NGN must be less than or equal to the number of energy groups in the DOT-IIW or DOT problem.
		13 - 24	NPL	P_l scattering approximation used in the DOT-IIW or DOT problem which generated the input data tape of angular fluxes.
		25 - 36	NQI	Number of discrete ordinate quadrature directions at the source surface. (The DOT-IIW or DOT angular flux data input to MAP on magnetic tape).
		37 - 48	NQIU	Number of upward directed (positive η) discrete ordinate quadrature directions at the source surface. (The DOT-IIW or DOT angular flux data input to MAP on magnetic tape).
		49 - 60	NQJ	Number of discrete ordinate quadrature directions at the detector surface. (The MAP output angular flux data in DOT-IIW).
		61 - 72	NQJU	Number of upward directed discrete ordinate quadrature directions (positive η) at the detector surface. (The MAP output angular flux data on magnetic tape for use in DOT-IIW).
5	6I12	-----	-----	Code logic and output options.
		1 - 12	NIT	Angular flux interpolation technique control. 0 - No interpolation 1 - Single variable interpolation technique

DATA SET 2 (CONTINUED)

Card	Format	Column	Variable	Description
		13 - 24	NPNH	Tape and punched output data option 0 - No punched card or magnetic tape output 1 - Scalar flux data at all detector points on the detector surface are punched on cards in a (6E12.5) format. Data are obtained for all points by groups for the total (sum of top or bottom and side), top or bottom, and side source surfaces. 2 - Angular flux data at all detector points on the detector surface by group are placed on magnetic tape for direct use as a boundary source input tape to DOT-IIW. 3 - Output data for NPNH=1 and 2 are obtained from problem.
		25 - 36	NPRT	Printed output data option

Printed Data Sets

Set No.	Input Data
1	MAP Input Data and Calculated Data for Problem Initialization.
2	MAP Geometry Data
3	DOT-IIW or DOT source surface angular flux data
4	MAP detector surface angular flux data
5	MAP detector surface scalar flux data and response data
6	Detailed geometry data (large quantity for checkout only)

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DATA SET 2 (CONTINUED)

Card	Format	Column	Variable	Description
				Options -1 - Print Data Sets 1, 2, 3, 4, 5, 6 0 - Print Data Sets 1, 2, 3, 4, 5 1 - Print Data Sets 1, 3, 4, 5 2 - Print Data Sets 1, 4, 5 3 - Print Data Sets 1, 5
6	6I12	-----	-----	Ray trace geometry input parameters. If NZN=0, no ray trace geometry data input is required and only void tracing for the source surface to detector surface is performed.
		1 - 12	NZ	Number of zones in ray trace geometry. NOTE: DOT-IIW or DOT cylindrical surface, which defines the MAP source surface, need not be defined as a zone since ray traces are performed for outward directions. Dimensions of the source surface in the ray trace geometry, if included, must not correspond to the DOT-IIW problem exterior surface or ray trace errors will occur.
		13 - 24	NE	Number of component materials in component-mixture table. If cross section data (SIG) are input on cards, then NE=0 and NBA=0.
		25 - 36	NM	Number of mixture materials in component-mixture table. If cross section data (SIG) are input on cards, then NM must correspond to the number of sets of SIG data.
		37 - 48	NB	Number of quadratic boundary surfaces in ray trace geometry.

DATA SET 2 (CONTINUED)

Card	Format	Column	Variable	Description
		49 - 60	NBA	Cross Section Data Input Option 0 - Input macroscopic cross sections for NM materials 1 - Calculate cross sections (photon only) from library tape and internal calculations, library tape is mounted on Tape 12.
		61 - 72	MBT	Multiple Scattering (buildup option) 0 - Do not compute buildup factor in ray trace geometry material penetration N - Compute buildup factors in ray trace geometry using data set N as described in Table 3-1.
7	6I12	---	---	
		1-12	NTSUR	Detector surface geometry option 1 - Plane detector surface defined by a set of radial mesh lines describing radial mesh intervals at a constant axial dimension. Plane is normal to Z axis (i.e., DOT-IIW problem axis) and the midpoint of intervals define the detector points. 2 - Meridian ring detector surface defined by a set of angular mesh lines describing the angular mesh intervals on a meridian ring. Midpoint of intervals define detector points. Data are entered in the cosine of the polar angle, cos α, where α is measured from the positive Z axis. 3 - Cylindrical detector surface defined by a set of axial mesh lines describing axial mesh intervals at a constand radial dimension. Surface is normal to the R axis and the midpoints of intervals define the detector points.

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DATA SET 2 (CONTINUED)

Card	Format	Column	Variable	Description
				4 – General detector surface defined by a set of radial (R) and axial (Z) detector point coordinates.
		13 - 24	NRJ	Number of detector points or mesh intervals at the detector surface
		25 - 36	NAT	Number of tagged surface areas on the top (or bottom) of the source surface area. A tagged surface area is a set of contiguous mesh intervals on the top, bottom or side source surface defined by the left and right or bottom and top mesh interval numbers of the source surface area to be tagged. Results are provided for each tagged surface area.
		37 - 48	NAS	Number of tagged surface areas on the side of the source surface area. (See description for NAT above)
		49 - 60	NRP	Number of sets of response function data. At least one set of data, NRP≥1, must be input for the code to function properly.
8	6E12.5	-----	-----	Problem Normalization and Detector Surface Data
		1 - 12	SCALE	Scale or normalization factor for all output data. SCALE is a constant multiplier applied to all output results and can be used to provide absolute magnitude results. If SCALE is input as 0.0, then SCALE is set equal to 1.0.
		13 - 24	ZR	Detector (or coupling) plane axial coordinate in reference to the first axial mesh line of the DOT-IIW or DOT geometry model dimensions. {NTSUR=1}

Card	Format	Column	Variable	Description
		25 - 36	RZ	Detector sphere (meridian ring) radius {NTSUR=2}
		37 - 48	ZM	Axial coordinate of the detector sphere (meridian ring) origin. The X and Y coordinates are assumed to be 0.0. {NTSUR=2}
		49 - 60	RL	Detector cylinder radius {NTSUR=3}

TABLE 3-1

LIBRARY OF BIVARIANT POLYNOMIAL
DATA FOR GAMMA RAY BUILDUP COEFFICIENT EVALUATION

MBT Value	Material	Buildup Type	Applicable Ranges E_G(lower)	Applicable Ranges E_G(upper)	Applicable Ranges b_t(upper)*
1	Water	Dose	0.255	10.0	20.0
2	Water	Energy	"	"	"
3	Water	Energy Absorption	"		
4	Aluminum	Dose	0.5		
5	Aluminum	Energy			
6	Aluminum	Energy Absorption			
7	Iron	Dose			
8	Iron	Energy			
9	Iron	Energy Absorption			
10	Uranium	Dose			15.0
11	Uranium	Energy			
12**	Uranium	Energy Absorption			
13	Lead	Dose			
14	Lead	Energy			
15	Lead	Energy Absorption			
17	Tin	Dose			
19	Tin	Energy			
21	Tin	Energy Absorption			
23	Tungsten	Dose			
25	Tungsten	Energy			
27	Tungsten	Energy Absorption			
			0.5	10.0	15.0

*b_t(lower) = 0.0 for all data, where b_t is the mean free path

**Data does not exist in Library

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DATA SET 3 – SOURCE SURFACE, DISCRETE ORDINATE QUADRATURE, DETECTOR SURFACE, AND RESPONSE DATA

Array	Data Type	Variable	Description
1	* or U	R1	Radial mesh line coordinates (centimeters) at the source surface. Data must be consistent with the DOT-IIW or DOT input data. /NRI+1 Values/
2	* or U	ZI	Axial mesh line coordinates (centimeters) at the source surface. Data must be consistent with the DOT-IIW or DOT input data. /NZI+1 Values/
3	* or U	CTQ	Azimuthal mesh line coordinates (degrees) defining the azimuthal mesh intervals on the (top or bottom) source surface. NOTE: CTQ(1)=0° and CTQ(NMU+1)=180°. /NMU+1 Values/
4	* or U	CSQ	Azimuthal mesh line coordinates (degrees) defining the azimuthal mesh intervals on the side source surface. NOTE: CSQ(1)≡0°. The code normalizes the side surface mesh interval widths to the angular width of the visible side surface.
5	$	NTGT	Tagged surface mesh interval numbers for the top (or bottom) surface. A set of 2 values of NTGT define the left and right mesh intervals bounding a contiguous set of mesh intervals for which the surface integeal detector response will be calculated. NTGT(1, 1) - NTGT (2, 1) define the first tagged surface on top (or bottom) surface. NTGT(1, 2) - NTGT (2,2) define the second tagged surface on top (or bottom) surface.

DATA SET 3 (CONTINUED)

Array	Data Type	Variable	Description
6	$	NTGS	Tagged surface mesh interval numbers for the side surface. A set of 2 values of NTGS define the bottom and top mesh intervals bounding a contiguous set of mesh intervals for which the surface integral detector response will be calculated. (See NTGT for details)
8	* or U	BI	Discrete ordinate quadrature data at source surface describing the DOT-IIW (or DOT) input angular flux data. Data are required for the discrete direction cosines μ, η and the discrete direction quadrature weights, W in the order of μ, η, and W. /NQI values of μ, NQI Values of η, NQI values of W/
10	* or U	CI	Discrete ordinate quadrature data of detector surface describing the MAP output angular flux data. Data are required for the discrete direction cosines, μ, η, and the discrete ordinate quadrature weights, W, in the order of μ, η, and W. /NQI values of μ, NQJ values of η, NQI values of W/
11	H	TITLE	Descriptive titles of response functions with each card containing one title. /NRP titles/
12	* or U	DOSE	Multigroup response function data. /NRP sets of data with each set containing NGN values/
13	* or U	RJ	/If NTSUR=4/ Radial coordinates (cm) of point detectors /NRJ values/

DATA SET 3 (CONTINUED)

Array	Data Type	Variable	Description
14	* or U	ZJ	/If NTSUR=4/ Axial coordinates (cm) of point detectors /NRJ Values/
15	* or U	R2	/If NTSUR=1, 3/ Mesh lines defining the detector surface mesh intervals. If NTSUR= 1, then radial mesh line coordinates (cm) at detector plane surface are input. If NTSUR=3, then axial mesh line coordinates (cm) of detector cylindrical surface are input. /NRJ+1 values/
16	* or U	R2	/NTSUR=2/ Angular mesh line coordinates (cosine of the polar angle α) at the detector sphere surface meridian ring) are input.
---	T	---	TERMINATE Cord

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DATA SET 4 - RAY TRACE GEOMETRY DATA, REQUIRED ONLY IF NZN>0

Array	Data Type	Variable	Description
1	$	NBZ	Number of boundary surfaces per geometry zone /NZN values/
2	$	NBD	Boundary surface numbers of the intersecting quadratic boundary surface which define the geometry zone. Six (6) values per zone must be entered with non-zero numbers for NBZ values for each zone. The ambiguity index (+ or -) of each boundary is assigned initially by the MAP ray trace ~~technique~~ subroutine. /NBZ sets of 6 values/
3	$	NTR	Boundary surface crossing zone numbers. NTR defines the zone entered upon crossing for boundary surface of a zone. Six (6) values per zone must be entered with non-zero numbers for NBZ /NBZ sets of 6 values/
4	$	NBE	Boundary surface equation type. See Table 3-2 for definition of equation types and required input values. /NB values/
5	* or U	X0	Boundary surface coefficients. See Table 3-2 for definition of required input by equation type NBE. Only required if non-zero and FIDO input operations can be used to place value at correct boundary number./NB values/
6	* or U	Y0	Boundary surface coefficients. See Table 3-2 for definition of required input by equation type NBE. Only required if non-zero and FIDO input operations can be used to place value at correct boundary number. /NB values/

TABLE 3-2

GEOMETRY BOUNDARY SURFACE TYPES

Boundary Equation Type (NBE)	Quadratic Equation	Input Values Required
1	$Ax^2 + By^2 + Cz^2 + x_o x + Y_o Y + Z_o Z - D = 0.0$	$A, B, C, x_o, Y_o, Z_o, D$
2	$A(x-x_o)^2 + B(Y-Y_o)^2 + C(z-z_o)^2 - D = 0.0$	$A, B, C, x_o, Y_o, z_o, D$
3	$(X-X_o)^2 + (Y-Y_o)^2 + (z-z_o)^2 - D = 0.0$	X_o, Y_o, Z_o, D
4	$X - D = 0.0$	D
5	$Y - D = 0.0$	D
6	$Z - D = 0.0$	D
7	$Ax^2 + By^2 + Cz^2 + x_o x + Y_o Y + Z_o Z - D^2 = 0.0$	$A, B, C, x_o, Y_o, Z_o, D$
8	$A(x-x_o)^2 + B(y-y_o)^2$	$A, B, C, x_o, Y_o, Z_o, D$
9	$(X-X_o)^2 + (Y-Y_o)^2 + (Z-Z_o)^2 - D^2 = 0.0$	X_o, Y_o, Z_o, D

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DATA SET 4 (CONTINUED)

Array	Data Type	Variable	Description
7	* or U	Z0	Boundary surface coefficients. See Table 3-2 for definition of required input by equation type NBE. Only required if non-zero and FIDO input operations can be used to place value at correct boundary number. /NB values/
8	* or U	A0	Boundary surface coefficients. See Table 3-2 for definition of required input by equation type NBE. Only required if non-zero and FIDO input operations can be used to place value at correct boundary number. /NB values/
9	* or U	B0	Boundary surface coefficients. See Table 3-2 for definition of required input by equation type NBE. Only required if non-zero and FIDO input operations can be used to place value at correct boundary number. /NB values/
10	* or U	C0	Boundary surface coefficients. See Table 3-2 for definition of required input by equation type NBE. Only required if non-zero and FIDO input operations can be used to place value at correct boundary number. /NB values/
11	* or U	D0	Boundary surface coefficients. See Table 3-2 for definition of required input by equation type NBE. Only required if non-zero and FIDO input operations can be used to place value at correct boundary number. /NB values/

DATA SET 4 (CONTINUED)

Array	Data Type	Variable	Description
12	* or U	EG	Average energy of each energy group. EG's are used in computation of group total photon cross sections if NBA>0 and in the computation of building factor for the MBT input value. /NGN values/
13	* or U	ZOE	Atomic number of elements in component element-material mixture table. /NE values/
14	* or U	COM	Partial densities (gm/cm^3) of component elements in material mixtures. /NE values for each of NM sets/
15	$	NMZ	Material mixture in each geometry zone. NMZ assigns the cross section set SIG to be used in each zone. /NZN values/
16	* or U	XP0	X, Y, and Z coordinates of a point in each zone of the geometry. XP0 is used to assign the ambiguity index of each boundary of each zone. /3 values for each of NZN sets/
17	* or U	SIG	/If NBA=0/ macroscopic multigroup cross sections for each zone. If NBA= 0, then SIG values are required for each group and each zone. If NBA>0, then the MAP code will calculate the values of SIG. /NGN values for each of NM sets/
---	T	---	TERMINATE Card

This concludes the required input for a MAP code problem. Stacked cases may be input input beginning with Card 2 in Data Set 2.

3.3 PROBLEM SIZE DETERMINATION

To determine the number of core memory storage locations required for data of a given problem, each of the expressions below should be evaluated and summed as noted. The value of the sum, including the conditions imposed on the expressions, will provide the value of the required input parameter, ISIZE, on card 1 of Data Set 1. For a MAP problem to run successfully, the input value of ISIZE must be equal to or greater than the calculated value of LAST. All quantities in the expressions below are required input quantities discussed in Section 3.2 except where defined. The symbolism, Max $[x_1, x_2 \ldots]$, signifies the maximum value of the quantities or expressions, x_i in the brackets is used in the calculation of the overall expression.

<u>MAP Flexible Dimension Data Storage Requirements</u>

If NZ equal to 0:

$$LAST = A + C$$

If NZ is greater than 0:

$$LAST = Max\,[A + B + C,\ A + B + D]$$

where:

$$A = 2 \cdot (NRI + NZI + NAT + NAS) + NMU + NMUS + 11 \cdot (NQI + NQJ) + NRP \cdot (18 + NGN) + 3 \cdot NRJ + 205$$

$$B = 17 \cdot NZ + 8 \cdot NB + NE + NGN \cdot (NM + 2) + NM \cdot (NE + 1) + IUI$$

$$C = IUI \cdot (3 + 2 \cdot NSN) + (3 + NAT + NAS) \cdot (NRJ + 2) + NQI \cdot (NRI + NZI) + 2 \cdot (NRJ \cdot NQJ + INMU) + INI + 4 \cdot NRJ + Max\,(IUI, IRP) + 5 \cdot NSN$$

$$D = 4 \cdot NZ + 2 \cdot INMU + IUI \cdot NGN$$

and:

$$IUI = Max\left[NMU \cdot Max\,[NRI, NRK]\ ,\ NMUS \cdot Max\,[NZI, NZK]\right]$$

$$INMU = Max\,[NMU, NMUS]$$

$$INI = Max\,[NRI, NRK, NZI, NZK]$$

$$IRP = (3 + NAT + NAS) \cdot NRJ \cdot NRP$$

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NSN = 0, if NIT equal to 0

$$NSN = \frac{\sqrt{16 + 8 \cdot NQI} - 4}{2}, \text{ If NIT is greater than 0.}$$

The quantity NSN is the quadrature order of the symmetric quadrature (i. e., S_n, n = 2, 4, 6 . . .) and NQI is the total number of discrete directions.

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3.4 DESCRIPTION OF QUADRATURE DATA SETS

Symmetric Quadrature Sets

In the solution of the Boltzmann transport equation employed in the DOT-IIW (or DOT) code integration over the $\vec{\Omega}$ direction variable is necessary. In obtaining a numerical solution in the versions of the DOT code, this integration is performed by mechanical quadrature, where the continuous variable, $\vec{\Omega}$, is represented by a set of discrete directions (Ω_s) and a corresponding set of weights (p_s). These directions are then equivalent to a set of points upon a unit sphere with origin at R. This mechanical quadrature representation is achieved using a set of direction cosines (μ_m, η_m) for the discrete directions (Ω_s) and a set of level weights (w_m) for the sum of the point weights (p_s) over the level m.

The development of the MAP code has included the use of the same generalized angular quadrature data acceptable to the DOT-IIW code; the MAP code will perform calculations using either symmetric or asymmetric quadrature data. However, the use of angular flux interpolation is limited to symmetric quadrature data. In addition, the recommended symmetric quadrature data for use in DOT-IIW-MAP coupled calculations using angular flux interpolation is that data based on a Gaussian mechanical quadrature.

A number of sets of angular quadrature data which have been developed for use in DOT-IIW and MAP are listed in Tables 3-3, 3-4, and 3-5. The data in Table 3-3 are S_4, S_6, S_8, and S_{10} discrete ordinate quadrature data sets. These data were calculated using Gaussian mechanical quadrature abscissas and weights[4]. The data are based on half symmetry conditions imposed on the selection and solution of the moments equations defining the discrete ordinate direction cosine and point weights[5]. The data in Table 3-3 are recommended for use in DOT-IIW and MAP when angular flux interpolation in MAP is used.

The set of angular quadrature data in Table 3-4 satisfies the requirements for rotation-reflection invariance with respect to 90° axis rotations and with respect to reflections about an axis, axes, and the origin. These concepts are discussed in Reference 10 as a basis for the selection of a generalized quadratrue data set. This standard set of mechanical quadrature data was generated and in no way biases the results with respect to

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geometrical axis. This set of completely symmetric quadrature data sets satisfies certain even moment conditions as well as rotational invariance. These sets are listed in Table 3-4 for S_2, S_4, S_6, S_8, S_{12}, S_{16} angular quadrature and are recommended for r, z, or x, y geometries.

The asymmetric set of anuglar quadrature data in Table 3-5 were developed for analysis of radiation transport close to the z axis of an r, z geometry problem. The S_{10} and S_6 angular quadrature data sets in Table 3-3 were used as base sets and S_{96} Gaussian mechanical quadrature abscissas and weights were used to preferentially subdivide the first η level of the S_{10} set into eleven sublevels. Further asymmetry was assigned in the azimuthal angle, M. The azimuthal asymmetry places discrete directions in close proximity to the r, z plane in which DOT-IIW solves for the angular flux.

The angular quadrature data in Tables 3-3, 3-4, and 3-5 satisfy the basic relationships defined by:

$$\sum_{m=1}^{M} w_m = 1.0$$

that:

$$\sum_{m=1}^{M} \eta_m \mu_m w_m = 0.0$$

and that:

$$\mu_m \neq 0.0 \text{ and } \eta_m \neq 0 \text{ for all } m$$

The MAP code performs these data checks on the input angular quadrature data; error messages are returned if the data are not consistent with these tests.

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The symmetric and asymmetric quadrature data set parameters required as input to the MAP code are listed in Table 3-6. The total number of quadrature angles and the number of upward directed angles are (+ηdirection) the only required parameters input for MAP. These data are necessary for the source and detector surface in MAP.

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TABLE 3-3

GAUSSIAN MECHANICAL QUADRATURE SETS WHOSE ABCISSAS ARE THE ZEROS OF LEGENDRE POLYNOMIALS. FOR X, Y AND R, Z GEOMETRIES

S4 ANGULAR QUADRATURE

```
 8U
-.508374127 -.339981043  .339981043 -.940432289 -.861136312 -.339981043
 .339981043  .861136312 -.508374127 -.339981043  .339981043 -.940432289
-.861136312 -.339981043  .339981043  .861136312
-.861136312 -.861136312 -.861136312 -.339981043 -.339981043 -.339981043
-.339981043 -.339981043  .861136312  .861136312  .861136312  .339981043
 .339981043  .339981043  .339981043  .339981043

 0.0         .0869637113 .0869637113 0.0         .0869637113 .0760725774
.0760725774 .0869637113 0.0          .0869637113 .0869637113 0.0
 .0869637113 .0760725774 .0760725774 .0869637113.
  T
```

S6 ANGULAR QUADRATURE

```
 8U
-0.361248675-0.238619186 0.238619186-0.750201405-0.661209386-0.238619186
 0.238619186 0.661209386-0.971113219-0.932469514-0.661209386-0.238619186
 0.238619186 0.661209386 0.932469514-0.361248675-0.238619186 0.238619186
-0.750201405-0.661209386-0.238619186 0.238619186 0.661209386-0.971113219
-0.932469514-0.661209386-0.238619186 0.238619186 0.661209386 0.932469514
-0.932469514-0.932469514-0.932469514-0.661209386-0.661209386-0.661209386
-0.661209386-0.661209386-0.238619186-0.238619186-0.238619186-0.238619186
-0.238619186-0.238619186-0.238619186 0.932469514 0.932469514 0.932469514
 0.661209386 0.661209386 0.661209386 0.661209386 0.661209386 0.238619186
 0.238619186 0.238619186 0.238619186 0.238619186 0.238619186 0.238619186

 0.000000000 0.042831123 0.042831123 0.000000000 0.055238669 0.034951723
 0.034951723 0.055238669 0.000000000 0.042831123 0.034951723 0.039195637
 0.039195637 0.034951723 0.042831123 0.000000000 0.042831123 0.042831123
 0.000000000 0.055238669 0.034951723 0.034951723 0.055238669 0.000000000
 0.042831123 0.034951723 0.039195637 0.039195637 0.034951723 0.042831123
  T
```

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TABLE 3-3 (CONTINUED)

S8 ANGULAR QUADRATURE

8U

-.279004286	-.183434642	.183434642	-.604419162	-.525532410	-.183434642
.183434642	.525532410	-.850773581	-.796666477	-.525532410	-.183434642
.183434642	.525532410	.796666477	-.983031908	-.960289856	-.796666477
-.525532410	-.183434642	.183434642	.525532410	.796666477	.960289856
-.279004286	-.183434642	.183434642	-.604419162	-.525532410	-.183434642
.183434642	.525532410	-.850773581	-.796666477	-.525532410	-.183434642
.183434642	.525532410	.796666477	-.983031908	-.960289856	-.796666477
-.525532410	-.183434642	.183434642	.525532410	.796666477	.960289856
-.960289856	-.960289856	-.960289856	-.796666477	-.796666477	-.796666477
-.796666477	-.796666477	-.525532410	-.525532410	-.525532410	-.525532410
-.525532410	-.525532410	-.525532410	-.183434642	-.183434642	-.183434642
-.183434642	-.183434642	-.183434642	-.183434642	-.183434642	-.183434642
.960289856	.960289856	.960289856	.796666477	.796666477	.796666477
.796666477	.796666477	.525532410	.525532410	.525532410	.525532410
.525532410	.525532410	.525532410	.183434642	.183434642	.183434642
.183434642	.183434642	.183434642	.183434642	.183434642	.183434642

0.000000000	.025307134	.025307134	0.000000000	.035623208	.019972050
.019972050	.035623208	0.000000000	.035623208	.016251849	.026551604
.026551604	.016251849	.035623208	0.000000000	.025307134	.019972050
.026551604	.018840157	.018840157	.026551604	.019972050	.025307134
0.000000000	.025307134	.025307134	0.000000000	.035623208	.019972050
.019972050	.035623208	0.000000000	.035623208	.016251849	.026551604
.026551604	.016251849	.035623208	0.000000000	.025307134	.019972050
.026551604	.018840157	.018840157	.026551604	.019972050	.025307134

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TABLE 3-3 (CONTINUED)

S10 ANGULAR QUADRATURE

8U

-.226949496	-.148874339	.148874339	-.501662608	-.433395394	-.148874339
.148874339	.433395394	-.733759251	-.679409568	-.433395394	-.148874339
.148874339	.433395394	.679409568	-.901203879	-.865063367	-.679409568
-.433395394	-.148874339	.148874339	.433395394	.679409568	.865063367
-.988856123	-.973906528	-.865063367	-.679409568	-.433395394	-.148874339
.148874339	.433395394	.679409568	.865063367	.973906528	-.226949496
-.148874339	.148874339	-.501662608	-.433395394	-.148874339	.148874339
.433395394	-.733759251	-.679409568	-.433395394	-.148874339	.148874339
.433395394	.679409568	-.901203879	-.865063367	-.679409568	-.433395394
-.148874339	.148874339	.433395394	.679409568	.865063367	-.988856123
-.973906528	-.865063367	-.679409568	-.433395394	-.148874339	.148874339
.433395394	.679409568	.865063367	.973906528		
-.973906528	-.973906528	-.973906528	-.865063367	-.865063367	-.865063367
-.865063367	-.865063367	-.679409568	-.679409568	-.679409568	-.679409568
-.679409568	-.679409568	-.679409568	-.433395394	-.433395394	-.433395394
-.433395394	-.433395394	-.433395394	-.433395394	-.433395394	-.433395394
-.148874339	-.148874339	-.148874339	-.148874339	-.148874339	-.148874339
-.148874339	-.148874339	-.148874339	-.148874339	-.148874339	.973906528
.973906528	.973906528	.865063367	.865063367	.865063367	.865063367
.865063367	.679409568	.679409568	.679409568	.679409568	.679409568
.679409568	.679409568	.433395394	.433395394	.433395394	.433395394
.433395394	.433395394	.433395394	.433395394	.433395394	.148874339
.148874339	.148874339	.148874339	.148874339	.148874339	.148874339
.148874339	.148874339	.148874339	.148874339		

0.000000000	.016667836	.016667836	0.000000000	.024441937	.012920900
.012920900	.024441937	0.000000000	.027011124	.008549830	.019210637
.019210637	.008549830	.027011124	0.000000000	.024441937	.008549830
.027468304	.006856609	.006856609	.027468304	.008549830	.024441937
0.000000000	.016667836	.012920900	.019210637	.006856609	.018225074
.018225074	.006856609	.019210637	.012920900	.016667836	0.000000000
.016667836	.016667836	0.000000000	.024441937	.012920900	.012920900
.024441937	0.000000000	.027011124	.008549830	.019210637	.019210637
.008549830	.027011124	0.000000000	.024441937	.008549830	.027468304
.006856609	.006856609	.027468304	.008549830	.024441937	0.000000000
.016667836	.012920900	.019210637	.006856609	.018225074	.018225074
.006856609	.019210637	.012920900	.016667836		

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TABLE 3-4

COMPLETELY SYMMETRIC QUADRATURE SETS SATISFYING CERTAIN EVEN MOMENT CONDITIONS FOR X, Y AND R, Z GEOMETRIES

S2 ANGULAR QUADRATURE

```
8U
-0.816500000-0.577350000 0.577350000-0.816500000-0.577350000 0.57735000
-0.577350000-0.577350000-0.577350000 0.577350000 0.577350000 0.577350000

0.000000000 0.250000000 0.250000000 0.000000000 0.250000000 0.250000000
 T
```

S4 ANGULAR QUADRATURE

```
8U
-.495004728 -.350021200  .350021200 -.936741778 -.868890280 -.350021200
 .350021200  .868890280 -.495004728 -.350021200  .350021200 -.936741778
-.868890280 -.350021200  .350021200  .868890280
-.868890280 -.868890280 -.868890280 -.350021200 -.350021200 -.350021200
-.350021200 -.350021200  .868890280  .868890280  .868890280  .350021200
 .350021200  .350021200  .350021200  .350021200

0.000000000  .083333333  .083333333 0.000000000  .083333333  .083333333
 .083333333  .083333333 0.000000000  .083333333  .083333333 0.000000000
 .083333333  .083333333  .083333333  .083333333
 T
```

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TABLE 3-4 (CONTINUED)

S6 ANGULAR QUADRATURE

8U

-.377079540	-.266635500	.266635500	-.731810935	-.681507707	-.266635500
.266635500	.681507707	-.963797442	-.926180879	-.681507707	-.266635500
.266635500	.681507707	.926180879	-.377079540	-.266635500	.266635500
-.731810935	-.681507707	-.266635500	.266635500	.681507707	-.963797442
-.926180879	-.681507707	-.266635500	.266635500	.681507707	.926180879
-.926180879	-.926180879	-.926180879	-.681507707	-.681507707	-.681507707
-.681507707	-.681507707	-.266635500	-.266635500	-.266635500	-.266635500
-.266635500	-.266635500	-.266635500	.926180879	.926180879	.926180879
.681507707	.681507707	.681507707	.681507707	.681507707	.266635500
.266635500	.266635500	.266635500	.266635500	.266635500	.266635500
0.000000000	.044031561	.044031561	0.000000000	.039301772	.039301772
.039301772	.039301772	0.000000000	.044031561	.039301772	.044031561
.044031561	.039301772	.044031561	0.000000000	.044031561	.044031561
0.000000000	.039301772	.039301772	.039301772	.039301772	0.000000000
.044031561	.039301772	.044031561	.044031561	.039301772	.044031561

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TABLE 3-4 (CONTINUED)

S8 ANGULAR QUADRATURE

8U

-.308606714	-.218217900	.218217900	-.617213403	-.577350269	-.218217900
.218217900	.577350269	-.816496581	-.786795790	-.577350269	-.218217900
.218217900	.577350269	.786795790	-.975900071	-.951189727	-.786795790
-.577350269	-.218217900	.218217900	.577350269	.786795790	.951189727
-.308606714	-.218217900	.218217900	-.617213403	-.577350269	-.218217900
.218217900	.577350269	-.816496581	-.786795790	-.577350269	-.218217900
.218217900	.577350269	.786795790	-.975900071	-.951189727	-.786795790
-.577350269	-.218217900	.218217900	.577350269	.786795790	.951189727
-.951189727	-.951189727	-.951189727	-.786795790	-.786795790	-.786795790
-.786795790	-.786795790	-.577350269	-.577350269	-.577350269	-.577350269
-.577350269	-.577350269	-.577350269	-.218217900	-.218217900	-.218217900
-.218217900	-.218217900	-.218217900	-.218217900	-.218217900	-.218217900
.951189727	.951189727	.951189727	.786795790	.786795790	.786795790
.786795790	.786795790	.577350269	.577350269	.577350269	.577350269
.577350269	.577350269	.577350269	.218217900	.218217900	.218217900
.218217900	.218217900	.218217900	.218217900	.218217900	.218217900

0.000000000	.030246915	.030246915	0.000000000	.022685185	.022685185
.022685185	.022685185	0.000000000	.022685185	.023148144	.022685185
.022685185	.023148144	.022685185	0.000000000	.030246915	.022685185
.022685185	.030246915	.030246915	.022685185	.022685185	.030246915
0.000000000	.030246915	.030246915	0.000000000	.022685185	.022685185
.022685185	.022685185	0.000000000	.022685185	.023148144	.022685185
.022685185	.023148144	.022685185	0.000000000	.030246915	.022685185
.022685185	.030246915	.030246915	.022685185	.022685185	.030246915

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TABLE 3-4 (CONTINUED)

S12 ANGULAR QUADRATURE

8U

-.236474327	-.167212600	.167212600	-.489023594	-.459547627	-.167212600
.167212600	.459547627	-.649898487	-.628019099	-.459547627	-.167212600
.167212600	.459547627	.628019099	-.778197925	-.760021024	-.628019099
-.459547627	-.167212600	.167212600	.459547627	.628019099	.760021024
-.888153128	-.872270557	-.760021024	-.628019099	-.459547627	-.167212600
.167212600	.459547627	.628019099	.760021024	.872270557	-.985920862
-.971637737	-.872270557	-.760021024	-.628019099	-.459547627	-.167212600
.167212600	.459547627	.628019099	.760021024	.872270557	.971637737
-.236474327	-.167212600	.167212600	-.489023594	-.459547627	-.167212600
.167212600	.459547627	-.649898487	-.628019099	-.459547627	-.167212600
.167212600	.459547627	.628019099	-.778197925	-.760021024	-.628019099
-.459547627	-.167212600	.167212600	.459547627	.628019099	.760021024
-.888153128	-.872270557	-.760021024	-.628019099	-.459547627	-.167212600
.167212600	.459547627	.628019099	.760021024	.872270557	-.985920862
-.971637737	-.872270557	-.760021024	-.628019099	-.459547627	-.167212600
.167212600	.459547627	.628019099	.760021024	.872270557	.971637737
-.971637737	-.971637737	-.971637737	-.872270557	-.872270557	-.872270557
-.872270557	-.872270557	-.760021024	-.760021024	-.760021024	-.760021024
-.760021024	-.760021024	-.760021024	-.628019099	-.628019099	-.628019099
-.628019099	-.628019099	-.628019099	-.628019099	-.628019099	-.628019099
-.459547627	-.459547627	-.459547627	-.459547627	-.459547627	-.459547627
-.459547627	-.459547627	-.459547627	-.459547627	-.459547627	-.167212600
-.167212600	-.167212600	-.167212600	-.167212600	-.167212600	-.167212600
-.167212600	-.167212600	-.167212600	-.167212600	-.167212600	-.167212600
.971637737	.971637737	.971637737	.872270557	.872270557	.872270557
.872270557	.872270557	.760021024	.760021024	.760021024	.760021024
.760021024	.760021024	.760021024	.628019099	.628019099	.628019099
.628019099	.628019099	.628019099	.628019099	.628019099	.628019099
.459547627	.459547627	.459547627	.459547627	.459547627	.459547627
.459547627	.459547627	.459547627	.459547627	.459547627	.167212600
.167212600	.167212600	.167212600	.167212600	.167212600	.167212600
.167212600	.167212600	.167212600	.167212600	.167212600	.167212600

0.000000000	.017690641	.017690641	0.000000000	.013970277	.013970277
.013970277	.013970277	0.000000000	.009334415	.012570495	.009334415
.009334415	.012570495	.009334415	0.000000000	.009334415	.006462814
.006462814	.009334415	.009334415	.006462814	.006462814	.009334415
0.000000000	.013970277	.012570495	.006462814	.012570495	.013970277
.013970277	.012570495	.006462814	.012570495	.013970277	0.000000000
.017690641	.013970277	.009334415	.009334415	.013970277	.017690641
.017690641	.013970277	.009334415	.009334415	.013970277	.017690641
0.000000000	.017690641	.017690641	0.000000000	.013970277	.013970277
.013970277	.013970277	0.000000000	.009334415	.012570495	.009334415
.009334415	.012570495	.009334415	0.000000000	.009334415	.006462814
.006462814	.009334415	.009334415	.006462814	.006462814	.009334415
0.000000000	.013970277	.012570495	.006462814	.012570495	.013970277
.013970277	.012570495	.006462814	.012570495	.013970277	0.000000000
.017690641	.013970277	.009334415	.009334415	.013970277	.017690641
.017690641	.013970277	.009334415	.009334415	.013970277	.017690641

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TABLE 3-4 (CONTINUED)

S16 ANGULAR QUADRATURE

8U

-.196514591	-.138956800	.138956800	-.416172855	-.392289246	-.138956800
.138956800	.392289246	-.554780772	-.537096559	-.392289246	-.138956800
.138956800	.392289246	.537096559	-.665104177	-.650426455	-.537096559
-.392289246	-.138956800	.138956800	.392289246	.537096559	.650426455
-.759569237	-.746750584	-.650426455	-.537096559	-.392289246	-.138956800
.138956800	.392289246	.537096559	.650426455	.746750584	-.843520768
-.831996571	-.746750584	-.650426455	-.537096559	-.392289246	-.138956800
.138956800	.392289246	.537096559	.650426455	.746750584	.831996571
-.919841914	-.909285519	-.831996571	-.746750584	-.650426455	-.537096559
-.392289246	-.138956800	.138956800	.392289246	.537096559	.650426455
.746750584	.831996571	.909285519	-.990298444	-.980500900	-.909285519
-.831996571	-.746750584	-.650426455	-.537096559	-.392289246	-.138956800
.138956800	.392289246	.537096559	.650426455	.746750584	.831996571
.909285519	.980500900	-.196514591	-.138956800	.138956800	-.416172855
-.392289246	-.138956800	.138956800	.392289246	-.554780772	-.537096559
-.392289246	-.138956800	.138956800	.392289246	.537096559	-.665104177
-.650426455	-.537096559	-.392289246	-.138956800	.138956800	.392289246
.537096559	.650426455	-.759569237	-.746750584	-.650426455	-.537096559
-.392289246	-.138956800	.138956800	.392289246	.537096559	.650426455
.746750584	-.843520768	-.831996571	-.746750584	-.650426455	-.537096559
-.392289246	-.138956800	.138956800	.392289246	.537096559	.650426455
.746750584	.831996571	-.919841914	-.909285519	-.831996571	-.746750584
-.650426455	-.537096559	-.392289246	-.138956800	.138956800	.392289246
.537096559	.650426455	.746750584	.831996571	.909285519	-.990298444
-.980500900	-.909285519	-.831996571	-.746750584	-.650426455	-.537096559
-.392289246	-.138956800	.138956800	.392289246	.537096559	.650426455
.746750584	.831996571	.909285519	.980500900		
-.980500900	-.980500900	-.980500900	-.909285519	-.909285519	-.909285519
-.909285519	-.909285519	-.831996571	-.831996571	-.831996571	-.831996571
-.831996571	-.831996571	-.831996571	-.746750584	-.746750584	-.746750584
-.746750584	-.746750584	-.746750584	-.746750584	-.746750584	-.746750584
-.650426455	-.650426455	-.650426455	-.650426455	-.650426455	-.650426455
-.650426455	-.650426455	-.650426455	-.650426455	-.650426455	-.537096559
-.537096559	-.537096559	-.537096559	-.537096559	-.537096559	-.537096559
-.537096559	-.537096559	-.537096559	-.537096559	-.537096559	-.537096559
-.392289246	-.392289246	-.392289246	-.392289246	-.392289246	-.392289246
-.392289246	-.392289246	-.392289246	-.392289246	-.392289246	-.392289246
-.392289246	-.392289246	-.392289246	-.138956800	-.138956800	-.138956800
-.138956800	-.138956800	-.138956800	-.138956800	-.138956800	-.138956800
-.138956800	-.138956800	-.138956800	-.138956800	-.138956800	-.138956800
-.138956800	-.138956800	.980500900	.980500900	.980500900	.909285519
.909285519	.909285519	.909285519	.909285519	.831996571	.831996571
.831996571	.831996571	.831996571	.831996571	.831996571	.746750584
.746750584	.746750584	.746750584	.746750584	.746750584	.746750584
.746750584	.746750584	.650426455	.650426455	.650426455	.650426455
.650426455	.650426455	.650426455	.650426455	.650426455	.650426455
.650426455	.537096559	.537096559	.537096559	.537096559	.537096559
.537096559	.537096559	.537096559	.537096559	.537096559	.537096559
.537096559	.537096559	.392289246	.392289246	.392289246	.392289246
.392289246	.392289246	.392289246	.392289246	.392289246	.392289246
.392289246	.392289246	.392289246	.392289246	.392289246	.138956800
.138956800	.138956800	.138956800	.138956800	.138956800	.138956800
.138956800	.138956800	.138956800	.138956800	.138956800	.138956800
.138956800	.138956800	.138956800	.138956800		

0.000000000	.012246801	.012246801	0.000000000	.010332403	.010332403
.010332403	.010332403	0.000000000	.005075791	.009476891	.005075791
.005075791	.009476891	.005075791	0.000000000	.006637520	.003382350

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TABLE 3-4 (CONTINUED)

.003382350	.006637520	.006637520	.003382350	.003382350	.006637520
0.000000000	.006637520	.008159281	.002594232	.008159281	.006637520
.006637520	.008159281	.002594232	.008159281	.006637520	0.000000000
.005075791	.003382350	.002594232	.002594232	.003382350	.005075791
.005075791	.003382350	.002594232	.002594232	.003382350	.005075791
0.000000000	.010332403	.009476891	.003382350	.008159281	.003382350
.009476891	.010332403	.010332403	.009476891	.003382350	.008159281
.003382350	.009476891	.010332403	0.000000000	.012246801	.010332403
.005075791	.006637520	.006637520	.005075791	.010332403	.012246801
.012246801	.010332403	.005075791	.006637520	.006637520	.005075791
.010332403	.012246801	0.000000000	.012246801	.012246801	0.000000000
.010332403	.010332403	.010332403	.010332403	0.000000000	.005075791
.009476891	.005075791	.005075791	.009476891	.005075791	0.000000000
.006637520	.003382350	.003382350	.006637520	.006637520	.003382350
.003382350	.006637520	0.000000000	.006637520	.008159281	.002594232
.008159281	.006637520	.006637520	.008159281	.002594232	.008159281
.006637520	0.000000000	.005075791	.003382350	.002594232	.002594232
.003382350	.005075791	.005075791	.003382350	.002594232	.002594232
.003382350	.005075791	0.000000000	.010332403	.009476891	.003382350
.008159281	.003382350	.009476891	.010332403	.010332403	.009476891
.003382350	.008159281	.003382350	.009476891	.010332403	0.000000000
.012246801	.010332403	.005075791	.006637520	.006637520	.005075791
.010332403	.012246801	.012246801	.010332403	.005075791	.006637520
.006637520	.005075791	.010332403	.012246801		
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TABLE 3-5

ASYMMETRIC QUADRATURE SETS SATISFYING CERTAIN EVEN MOMENT CONDITIONS WHICH ACHIEVE HIGH ANGULAR RESOLUTION IN THE DIRECTION OF THE Z AXIS (IN THE OPPOSITE HEMISPHERE, A COMPLETELY SYMMETRIC S6 QUADRATURE SET IS USED.)

80 ANGLES 49 DEGREES ON A LEVEL
15 ANGLES IN THE &ETA DIRECTION, 65 ANGLES IN THE -ETA DIRECTION

8U

-.024917777	-.016347532	.016347532	-.057171433	-.037507835	.037507835
-.089555393	-.058753624	.058753624	-.121887680	-.079965513	.079965513
-.154107249	-.101103452	.101103452	-.186171501	-.122139494	.122139494
-.218042951	-.143049047	.143049047	-.249686111	-.163808828	.163808828
-.281066512	-.184396223	.184396223	-.312150340	-.204789049	.204789049
-.342904308	-.224965467	.224965467	-.501663000	-.433395000	-.148874000
.148874000	.433395000	-.733759000	-.679410000	-.433395000	-.148874000
.148874000	.433395000	.679410000	-.901204000	-.865063000	-.679410000
-.433395000	-.148874000	.148874000	.433395000	.679410000	.865063000
-.988856000	-.973907000	-.865063000	-.679410000	-.433395000	-.148874000
.148874000	.433395000	.679410000	.865063000	.973907000	-.361249000
-.238619000	.238619000	-.750201000	-.661209000	-.238619000	.238619000
.661209000	-.971113000	-.932470000	-.661209000	-.238619000	.238619000
.661209000	.932470000				
-.999689504	-.999689504	-.999689504	-.998364376	-.998364376	-.998364376
-.995981843	-.995981843	-.995981843	-.992543900	-.992543900	-.992543900
-.988054126	-.988054126	-.988054126	-.982517263	-.982517263	-.982517263
-.975939174	-.975939174	-.975939174	-.968326828	-.968326828	-.968326828
-.959688291	-.959688291	-.959688291	-.950032718	-.950032718	-.950032718
-.939370340	-.939370340	-.939370340	-.865063000	-.865063000	-.865063000
-.865063000	-.865063000	-.679410000	-.679410000	-.679410000	-.679410000
-.679410000	-.679410000	-.679410000	-.433395000	-.433395000	-.433395000
-.433395000	-.433395000	-.433395000	-.433395000	-.433395000	-.433395000
-.148874000	-.148874000	-.148874000	-.148874000	-.148874000	-.148874000
-.148874000	-.148874000	-.148874000	-.148874000	-.148874000	.932470000
.932470000	.932470000	.661209000	.661209000	.661209000	.661209000
.661209000	.238619000	.238619000	.238619000	.238619000	.238619000
.238619000	.238619000				

0.000000000	.000199198	.000199198	0.000000000	.000463490	.000463490
0.000000000	.000727683	.000727683	0.000000000	.000991138	.000991138
0.000000000	.001253551	.001253551	0.000000000	.001514636	.001514636
0.000000000	.001774118	.001774118	0.000000000	.002031719	.002031719
0.000000000	.002287168	.002287168	0.000000000	.002540192	.002540192
0.000000000	.002884906	.002884906	0.000000000	.024441900	.012920900
.012920900	.024441900	0.000000000	.027011100	.008549830	.019210600
.019210600	.008549830	.027011100	0.000000000	.024441900	.008549830
.027468300	.006856610	.006856610	.027468300	.008549830	.024441900
0.000000000	.016667800	.012920900	.019210600	.006856610	.018225100
.018225100	.006856610	.019210600	.012920900	.016667800	0.000000000
.042831100	.042831100	0.000000000	.055238700	.034951700	.034951700
.055238700	0.000000000	.042831100	.034951700	.039195600	.039195600
.034951700	.042831100				

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C.53

TABLE 3-5 (CONTINUED)

80 ANGLES 49 DEGREES ON A LEVEL
65 ANGLES IN THE &ETA DIRECTION, 15 ANGLES IN THE -ETA DIRECTION

8U

-.361249000	-.238619000	.238619000	-.750201000	-.661209000	-.238619000
.238619000	.661209000	-.971113000	-.932470000	-.661209000	-.238619000
.238619000	.661209000	.932470000	-.024917777	-.016347532	.016347532
-.057171433	-.037507835	.037507835	-.089555393	-.058753624	.058753624
-.121887680	-.079965513	.079965513	-.154107249	-.101103452	.101103452
-.186171501	-.122139494	.122139494	-.218042951	-.143049047	.143049047
-.249686111	-.163808828	.163808828	-.281066512	-.184396223	.184396223
-.312150340	-.204789049	.204789049	-.342904308	-.224965467	.224965467
-.501663000	-.433395000	-.148874000	.148874000	.433395000	-.733759000
-.679410000	-.433395000	-.148874000	.148874000	.433395000	.679410000
-.901204000	-.865063000	-.679410000	-.433395000	-.148874000	.148874000
.433395000	.679410000	.865063000	-.988856000	-.973907000	-.865063000
-.679410000	-.433395000	-.148874000	.148874000	.433395000	.679410000
.865063000	.973907000				
-.932470000	-.932470000	-.932470000	-.661209000	-.661209000	-.661209000
-.661209000	-.661209000	-.238619000	-.238619000	-.238619000	-.238619000
-.238619000	-.238619000	-.238619000	.999689504	.999689504	.999689504
.998364376	.998364376	.998364376	.995981843	.995981843	.995981843
.992543900	.992543900	.992543900	.988054126	.988054126	.988054126
.982517263	.982517263	.982517263	.975939174	.975939174	.975939174
.968326828	.968326828	.968326828	.959688291	.959688291	.959688291
.950032718	.950032718	.950032718	.939370340	.939370340	.939370340
.865063000	.865063000	.865063000	.865063000	.865063000	.679410000
.679410000	.679410000	.679410000	.679410000	.679410000	.679410000
.433395000	.433395000	.433395000	.433395000	.433395000	.433395000
.433395000	.433395000	.433395000	.148874000	.148874000	.148874000
.148874000	.148874000	.148874000	.148874000	.148874000	.148874000
.148874000	.148874000				
0.000000000	.042831100	.042831100	0.000000000	.055238700	.034951700
.034951700	.055238700	0.000000000	.042831100	.034951700	.039195600
.039195600	.034951700	.042831100	0.000000000	.000199198	.000199198
0.000000000	.000463490	.000463490	0.000000000	.000727683	.000727683
0.000000000	.000991138	.000991138	0.000000000	.001253551	.001253551
0.000000000	.001514636	.001514636	0.000000000	.001774118	.001774118
0.000000000	.002031719	.002031719	0.000000000	.002287168	.002287168
0.000000000	.002540192	.002540192	0.000000000	.002884906	.002884906
0.000000000	.024441900	.012920900	.012920900	.024441900	0.000000000
.027011100	.008549830	.019210600	.019210600	.008549830	.027011100
0.000000000	.024441900	.008549830	.027468300	.006856610	.006856610
.027468300	.008549830	.024441900	0.000000000	.016667800	.012920900
.019210600	.006856610	.018225100	.018225100	.006856610	.019210600
.012920900	.016667800				

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TABLE 3-5 (CONTINUED)

102 ANGLES 1,49 DEGREES ON A LEVEL
87 ANGLES IN THE &ETA DIRECTION, 15 ANGLES IN THE -ETA DIRECTION

8U

-.024917777	-.024913982	-.016347532	.016347532	.024913982	-.057171433
-.057162725	-.037507835	.037507835	.057162725	-.089555393	-.089541753
-.058753624	.058753624	.089541753	-.121887680	-.121869116	-.079965513
.079965513	.121869116	-.154107249	-.154083777	-.101103452	.101103452
.154083777	-.186171501	-.186143147	-.122139494	.122139494	.186143147
-.218042951	-.218009742	-.143049047	.143049047	.218009742	-.249686111
-.249648083	-.163808828	.163808828	.249648083	-.281066512	-.281023704
-.184396223	.184396223	.281023704	-.312150340	-.312102798	-.204789049
.204789049	.312102798	-.342904308	-.342852082	-.224965467	.224965467
.342852082	-.501663000	-.433395000	-.148874000	.148874000	.433395000
-.733759000	-.679410000	-.433395000	-.148874000	.148874000	.433395000
.679410000	-.901204000	-.865063000	-.679410000	-.433395000	-.148874000
.148874000	.433395000	.679410000	.865063000	-.988856000	-.973907000
-.865063000	-.679410000	-.433395000	-.148874000	.148874000	.433395000
.679410000	.865063000	.973907000	-.361249000	-.238619000	.238619000
-.750201000	-.661209000	-.238619000	.238619000	.661209000	-.971113000
-.932470000	-.661209000	-.238619000	.238619000	.661209000	.932470000
-.999689504	-.999689504	-.999689504	-.999689504	-.999689504	-.998364376
-.998364376	-.998364376	-.998364376	-.998364376	-.995981843	-.995981843
-.995981843	-.995981843	-.995981843	-.992543900	-.992543900	-.992543900
-.992543900	-.992543900	-.988054126	-.988054126	-.988054126	-.988054126
-.988054126	-.982517263	-.982517263	-.982517263	-.982517263	-.982517263
-.975939174	-.975939174	-.975939174	-.975939174	-.975939174	-.968326828
-.968326828	-.968326828	-.968326828	-.968326828	-.959688291	-.959688291
-.959688291	-.959688291	-.959688291	-.950032718	-.950032718	-.950032718
-.950032718	-.950032718	-.939370340	-.939370340	-.939370340	-.939370340
-.939370340	-.865063000	-.865063000	-.865063000	-.865063000	-.865063000
-.679410000	-.679410000	-.679410000	-.679410000	-.679410000	-.679410000
-.679410000	-.433395000	-.433395000	-.433395000	-.433395000	-.433395000
-.433395000	-.433395000	-.433395000	-.433395000	-.148874000	-.148874000
-.148874000	-.148874000	-.148874000	-.148874000	-.148874000	-.148874000
-.148874000	-.148874000	-.148874000	.932470000	.932470000	.932470000
.661209000	.661209000	.661209000	.661209000	.661209000	.238619000
.238619000	.238619000	.238619000	.238619000	.238619000	.238619000

0.000000000	.000004427	.000194771	.000194771	.000004427	0.000000000
.000010300	.000453190	.000453190	.000010300	0.000000000	.000016171
.000711512	.000711512	.000016171	0.000000000	.000022025	.000969113
.000969113	.000022025	0.000000000	.000027857	.001225694	.001225694
.000027857	0.000000000	.000033659	.001480978	.001480978	.000033659
0.000000000	.000039425	.001734693	.001734693	.000039425	0.000000000
.000045149	.001986570	.001986570	.000045149	0.000000000	.000050826
.002236342	.002236342	.000050826	0.000000000	.000056449	.002483744
.002483744	.000056449	0.000000000	.000064109	.002820797	.002820797
.000064109	0.000000000	.024441900	.012920900	.012920900	.024441900
0.000000000	.027011100	.008549830	.019210600	.019210600	.008549830
.027011100	0.000000000	.024441900	.008549830	.027468300	.006856610
.006856610	.027468300	.008549830	.024441900	0.000000000	.016667800
.012920900	.019210600	.006856610	.018225100	.018225100	.006856610
.019210600	.012920900	.016667800	0.000000000	.042831100	.042831100
0.000000000	.055238700	.034951700	.034951700	.055238700	0.000000000
.042831100	.034951700	.039195600	.039195600	.034951700	.042831100

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TABLE 3-5 (CONTINUED)

102 ANGLES 1,49 DEGREES ON A LEVEL
15 ANGLES IN THE &ETA DIRECTION, 87 ANGLES IN THE -ETA DIRECTION

8U

-.361249000	-.238619000	.238619000	-.750201000	-.661209000	-.238619000
.238619000	.661209000	-.971113000	-.932470000	-.661209000	-.238619000
.238619000	.661209000	.932470000	-.024917777	-.024913982	-.016347532
.016347532	.024913982	-.057171433	-.057162725	-.037507835	.037507835
.057162725	-.089555393	-.089541753	-.058753624	.058753624	.089541753
-.121887680	-.121869116	-.079965513	.079965513	.121869116	-.154107249
-.154083777	-.101103452	.101103452	.154083777	-.186171501	-.186143147
-.122139494	.122139494	.186143147	-.218042951	-.218009742	-.143049047
.143049047	.218009742	-.249686111	-.249648083	-.163808828	.163808828
.249648083	-.281066512	-.281023704	-.184396223	.184396223	.281023704
-.312150340	-.312102798	-.204789049	.204789049	.312102798	-.342904308
-.342852082	-.224965467	.224965467	.342852082	-.501663000	-.433395000
-.148874000	.148874000	.433395000	-.733759000	-.679410000	-.433395000
-.148874000	.148874000	.433395000	.679410000	-.901204000	-.865063000
-.679410000	-.433395000	-.148874000	.148874000	.433395000	.679410000
.865063000	-.988856000	-.973907000	-.865063000	-.679410000	-.433395000
-.148874000	.148874000	.433395000	.679410000	.865063000	.973907000
-.932470000	-.932470000	-.932470000	-.661209000	-.661209000	-.661209000
-.661209000	-.661209000	-.238619000	-.238619000	-.238619000	-.238619000
-.238619000	-.238619000	-.238619000	.999689504	.999689504	.999689504
.999689504	.999689504	.998364376	.998364376	.998364376	.998364376
.998364376	.995981843	.995981843	.995981843	.995981843	.995981843
.992543900	.992543900	.992543900	.992543900	.992543900	.988054126
.988054126	.988054126	.988054126	.988054126	.982517263	.982517263
.982517263	.982517263	.982517263	.975939174	.975939174	.975939174
.975939174	.975939174	.968326828	.968326828	.968326828	.968326828
.968326828	.959688291	.959688291	.959688291	.959688291	.959688291
.950032718	.950032718	.950032718	.950032718	.950032718	.939370340
.939370340	.939370340	.939370340	.939370340	.865063000	.865063000
.865063000	.865063000	.865063000	.679410000	.679410000	.679410000
.679410000	.679410000	.679410000	.679410000	.433395000	.433395000
.433395000	.433395000	.433395000	.433395000	.433395000	.433395000
.433395000	.148874000	.148874000	.148874000	.148874000	.148874000
.148874000	.148874000	.148874000	.148874000	.148874000	.148874000

0.000000000	.042831100	.042831100	0.000000000	.055238700	.034951700
.034951700	.055238700	0.000000000	.042831100	.034951700	.039195600
.039195600	.034951700	.042831100	0.000000000	.000004427	.000194771
.000194771	.000004427	0.000000000	.000010300	.000453190	.000453190
.000010300	0.000000000	.000016171	.000711512	.000711512	.000016171
0.000000000	.000022025	.000969113	.000969113	.000022025	0.000000000
.000027857	.001225694	.001225694	.000027857	0.000000000	.000033659
.001480978	.001480978	.000033659	0.000000000	.000039425	.001734693
.001734693	.000039425	0.000000000	.000045149	.001986570	.001986570
.000045149	0.000000000	.000050826	.002236342	.002236342	.000050826
0.000000000	.000056449	.002483744	.002483744	.000056449	0.000000000
.000064109	.002820797	.002820797	.000064109	0.000000000	.024441900
.012920900	.012920900	.024441900	0.000000000	.027011100	.008549830
.019210600	.019210600	.008549830	.027011100	0.000000000	.024441900
.008549830	.027468300	.006856610	.006856610	.027468300	.008549830
.024441900	0.000000000	.016667800	.012920900	.019210600	.006856610
.018225100	.018225100	.006856610	.019210600	.012920900	.016667800

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TABLE 3-5 (CONTINUED)

102 ANGLES 2.5,49 DEGREES ON A LEVEL
15 ANGLES IN THE &ETA DIRECTION, 87 ANGLES IN THE -ETA DIRECTION

8U

-.024917777	-.024894060	-.016347532	.016347532	.024894060	-.057171433
-.057117018	-.037507835	.037507835	.057117018	-.089555393	-.089470156
-.058753624	.058753624	.089470156	-.121887680	-.121771670	-.079965513
.079965513	.121771670	-.154107249	-.153960573	-.101103452	.101103452
.153960573	-.186171501	-.185994307	-.122139494	.122139494	.185994307
-.218042951	-.217835423	-.143049047	.143049047	.217835423	-.249686111
-.249448465	-.163808828	.163808828	.249448465	-.281066512	-.280798999
-.184396223	.184396223	.280798999	-.312150340	-.311853242	-.204789049
.204789049	.311853242	-.342904308	-.342577939	-.224965467	.224965467
.342577939	-.501663000	-.433395000	-.148874000	.148874000	.433395000
-.733759000	-.679410000	-.433395000	-.148874000	.148874000	.433395000
.679410000	-.901204000	-.865063000	-.679410000	-.433395000	-.148874000
.148874000	.433395000	.679410000	.865063000	-.988856000	-.973907000
-.865063000	-.679410000	-.433395000	-.148874000	.148874000	.433395000
.679410000	.865063000	.973907000	-.361249000	-.238619000	.238619000
-.750201000	-.661209000	-.238619000	.238619000	.661209000	-.971113000
-.932470000	-.661209000	-.238619000	.238619000	.661209000	.932470000
-.999689504	-.999689504	-.999689504	-.999689504	-.999689504	-.998364376
-.998364376	-.998364376	-.998364376	-.998364376	-.995981843	-.995981843
-.995981843	-.995981843	-.995981843	-.992543900	-.992543900	-.992543900
-.992543900	-.992543900	-.988054126	-.988054126	-.988054126	-.988054126
-.988054126	-.982517263	-.982517263	-.982517263	-.982517263	-.982517263
-.975939174	-.975939174	-.975939174	-.975939174	-.975939174	-.968326828
-.968326828	-.968326828	-.968326828	-.968326828	-.959688291	-.959688291
-.959688291	-.959688291	-.959688291	-.950032718	-.950032718	-.950032718
-.950032718	-.950032718	-.939370340	-.939370340	-.939370340	-.939370340
-.939370340	-.865063000	-.865063000	-.865063000	-.865063000	-.865063000
-.679410000	-.679410000	-.679410000	-.679410000	-.679410000	-.679410000
-.679410000	-.433395000	-.433395000	-.433395000	-.433395000	-.433395000
-.433395000	-.433395000	-.433395000	-.433395000	-.148874000	-.148874000
-.148874000	-.148874000	-.148874000	-.148874000	-.148874000	-.148874000
-.148874000	-.148874000	-.148874000	.932470000	.932470000	.932470000
.661209000	.661209000	.661209000	.661209000	.661209000	.238619000
.238619000	.238619000	.238619000	.238619000	.238619000	.238619000

0.000000000	.000011067	.000188131	.000188131	.000011067	0.000000000
.000025749	.000437741	.000437741	.000025749	0.000000000	.000040427
.000687256	.000687256	.000040427	0.000000000	.000055063	.000936075
.000936075	.000055063	0.000000000	.000069642	.001183909	.001183909
.000069642	0.000000000	.000084146	.001430490	.001430490	.000084146
0.000000000	.000098562	.001675556	.001675556	.000098562	0.000000000
.000112873	.001918846	.001918846	.000112873	0.000000000	.000127065
.002160103	.002160103	.000127065	0.000000000	.000141122	.002399071
.002399071	.000141122	0.000000000	.000160273	.002724633	.002724633
.000160273	0.000000000	.024441900	.012920900	.012920900	.024441900
0.000000000	.027011100	.008549830	.019210600	.019210600	.008549830
.027011100	0.000000000	.024441900	.008549830	.027468300	.006856610
.006856610	.027468300	.008549830	.024441900	0.000000000	.016667800
.012920900	.019210600	.006856610	.018225100	.018225100	.006856610
.019210600	.012920900	.016667800	0.000000000	.042831100	.042831100
0.000000000	.055238700	.034951700	.034951700	.055238700	0.000000000
.042831100	.034951700	.039195600	.039195600	.034951700	.042831100

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TABLE 3-5 (CONTINUED)

102 ANGLES 2.5,49 DEGREES ON A LEVEL
87 ANGLES IN THE &ETA DIRECTION, 15 ANGLES IN THE -ETA DIRECTION

8U

-.361249000	-.238619000	.238619000	-.750201000	-.661209000	-.238619000
.238619000	.661209000	-.971113000	-.932470000	-.661209000	-.238619000
.238619000	.661209000	.932470000	-.024917777	-.024894060	-.016347532
.016347532	.024894060	-.057171433	-.057117018	-.037507835	.037507835
.057117018	-.089555393	-.089470156	-.058753624	.058753624	.089470156
-.121887680	-.121771670	-.079965513	.079965513	.121771670	-.154107249
-.153960573	-.101103452	.101103452	.153960573	-.186171501	-.185994307
-.122139494	.122139494	.185994307	-.218042951	-.217835423	-.143049047
.143049047	.217835423	-.249686111	-.249448465	-.163808828	.163808828
.249448465	-.281066512	-.280798999	-.184396223	.184396223	.280798999
-.312150340	-.311853242	-.204789049	.204789049	.311853242	-.342904308
-.342577939	-.224965467	.224965467	.342577939	-.501663000	-.433395000
-.148874000	.148874000	.433395000	-.733759000	-.679410000	-.433395000
-.148874000	.148874000	.433395000	.679410000	-.901204000	-.865063000
-.679410000	-.433395000	-.148874000	.148874000	.433395000	.679410000
.865063000	-.988856000	-.973907000	-.865063000	-.679410000	-.433395000
-.148874000	.148874000	.433395000	.679410000	.865063000	.973907000
-.932470000	-.932470000	-.932470000	-.661209000	-.661209000	-.661209000
-.661209000	-.661209000	-.238619000	-.238619000	-.238619000	-.238619000
-.238619000	-.238619000	-.238619000	.999689504	.999689504	.999689504
.999689504	.999689504	.998364376	.998364376	.998364376	.998364376
.998364376	.995981843	.995981843	.995981843	.995981843	.995981843
.992543900	.992543900	.992543900	.992543900	.992543900	.988054126
.988054126	.988054126	.988054126	.988054126	.982517263	.982517263
.982517263	.982517263	.982517263	.975939174	.975939174	.975939174
.975939174	.975939174	.968326828	.968326828	.968326828	.968326828
.968326828	.959688291	.959688291	.959688291	.959688291	.959688291
.950032718	.950032718	.950032718	.950032718	.950032718	.939370340
.939370340	.939370340	.939370340	.939370340	.865063000	.865063000
.865063000	.865063000	.865063000	.679410000	.679410000	.679410000
.679410000	.679410000	.679410000	.679410000	.433395000	.433395000
.433395000	.433395000	.433395000	.433395000	.433395000	.433395000
.433395000	.148874000	.148874000	.148874000	.148874000	.148874000
.148874000	.148874000	.148874000	.148874000	.148874000	.148874000

0.000000000	.042831100	.042831100	0.000000000	.055238700	.034951700
.034951700	.055238700	0.000000000	.042831100	.034951700	.039195600
.039195600	.034951700	.042831100	0.000000000	.000011067	.000188131
.000188131	.000011067	0.000000000	.000025749	.000437741	.000437741
.000025749	0.000000000	.000040427	.000687256	.000687256	.000040427
0.000000000	.000055063	.000936075	.000936075	.000055063	0.000000000
.000069642	.001183909	.001183909	.000069642	0.000000000	.000084146
.001430490	.001430490	.000084146	0.000000000	.000098562	.001675556
.001675556	.000098562	0.000000000	.000112873	.001918846	.001918846
.000112873	0.000000000	.000127065	.002160103	.002160103	.000127065
0.000000000	.000141122	.002399071	.002399071	.000141122	0.000000000
.000160273	.002724633	.002724633	.000160273	0.000000000	.024441900
.012920900	.012920900	.024441900	0.000000000	.027011100	.008549830
.019210600	.019210600	.008549830	.027011100	0.000000000	.024441900
.008549830	.027468300	.006856610	.006856610	.027468300	.008549830
.024441900	0.000000000	.016667800	.012920900	.019210600	.006856610
.018225100	.018225100	.006856610	.019210600	.012920900	.016667800

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TABLE 3-5 (CONTINUED)

124 ANGLES 1,17.5,49 DEGREES ON A LEVEL

15 ANGLES IN THE &ETA DIRECTION, 109 ANGLES IN THE -ETA DIRECTION

8U

-.024917777	-.024913982	-.023764506	-.012458888	.012458888	.023764506
.024913982	-.057171433	-.057162725	-.054525365	-.028585716	.028585716
.054525365	.057162725	-.089555393	-.089541753	-.085410496	-.044777696
.044777696	.085410496	.089541753	-.121887680	-.121869116	-.116246347
-.060943840	.060943840	.116246347	.121869116	-.154107249	-.154083777
-.146974695	-.077053624	.077053624	.146974695	.154083777	-.186171501
-.186143147	-.177554917	-.093085751	.093085751	.177554917	.186143147
-.218042951	-.218009742	-.207951259	-.109021476	.109021476	.207951259
.218009742	-.249686111	-.249648083	-.238129877	-.124843056	.124843056
.238129877	.249648083	-.281066512	-.281023704	-.268057897	-.140533256
.140533256	.268057897	.281023704	-.312150340	-.312102798	-.297703070
-.156075170	.156075170	.297703070	.312102798	-.342904308	-.342852082
-.327033651	-.171452154	.171452154	.327033651	.342852082	-.501663000
-.433395000	-.148874000	.148874000	.433395000	-.733759000	-.679410000
-.433395000	-.148874000	.148874000	.433395000	.679410000	-.901204000
-.865063000	-.679410000	-.433395000	-.148874000	.148874000	.433395000
.679410000	.865063000	-.988856000	-.973907000	-.865063000	-.679410000
-.433395000	-.148874000	.148874000	.433395000	.679410000	.865063000
.973907000	-.361249000	-.238619000	.238619000	-.750201000	-.661209000
-.238619000	.238619000	.661209000	-.971113000	-.932470000	-.661209000
-.238619000	.238619000	.661209000	.932470000		
-.999689504	-.999689504	-.999689504	-.999689504	-.999689504	-.999689504
-.999689504	-.998364376	-.998364376	-.998364376	-.998364376	-.998364376
-.998364376	-.998364376	-.995981843	-.995981843	-.995981843	-.995981843
-.995981843	-.995981843	-.995981843	-.992543900	-.992543900	-.992543900
-.992543900	-.992543900	-.992543900	-.992543900	-.988054126	-.988054126
-.988054126	-.988054126	-.988054126	-.988054126	-.988054126	-.982517263
-.982517263	-.982517263	-.982517263	-.982517263	-.982517263	-.982517263
-.975939174	-.975939174	-.975939174	-.975939174	-.975939174	-.975939174
-.975939174	-.968326828	-.968326828	-.968326828	-.968326828	-.968326828
-.968326828	-.968326828	-.959688291	-.959688291	-.959688291	-.959688291
-.959688291	-.959688291	-.959688291	-.950032718	-.950032718	-.950032718
-.950032718	-.950032718	-.950032718	-.950032718	-.939370340	-.939370340
-.939370340	-.939370340	-.939370340	-.939370340	-.939370340	-.865063000
-.865063000	-.865063000	-.865063000	-.865063000	-.679410000	-.679410000
-.679410000	-.679410000	-.679410000	-.679410000	-.679410000	-.433395000
-.433395000	-.433395000	-.433395000	-.433395000	-.433395000	-.433395000
-.433395000	-.433395000	-.148874000	-.148874000	-.148874000	-.148874000
-.148874000	-.148874000	-.148874000	-.148874000	-.148874000	-.148874000
-.148874000	.932470000	.932470000	.932470000	.661209000	.661209000
.661209000	.661209000	.661209000	.238619000	.238619000	.238619000
.238619000	.238619000	.238619000	.238619000		

0.000000000	.000004427	.000061973	.000132799	.000132799	.000061973
.000004427	0.000000000	.000010300	.000144197	.000308994	.000308994
.000144197	.000010300	0.000000000	.000016171	.000226390	.000485122
.000485122	.000226390	.000016171	0.000000000	.000022025	.000308354
.000660759	.000660759	.000308354	.000022025	0.000000000	.000027857
.000389994	.000835700	.000835700	.000389994	.000027857	0.000000000
.000033659	.000471220	.001009758	.001009758	.000471220	.000033659
0.000000000	.000039425	.000551948	.001182745	.001182745	.000551948
.000039425	0.000000000	.000045149	.000632090	.001354479	.001354479
.000632090	.000045149	0.000000000	.000050826	.000711563	.001524778
.001524778	.000711563	.000050826	0.000000000	.000056449	.000790282
.001693462	.001693462	.000790282	.000056449	0.000000000	.000064109
.000897526	.001923271	.001923271	.000897526	.000064109	0.000000000
.024441900	.012920900	.012920900	.024441900	0.000000000	.027011100
.008549830	.019210600	.019210600	.008549830	.027011100	0.000000000

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TABLE 3-5 (CONTINUFD)

.024441900	.008549830	.027468300	.006856610	.006856610	.027468300
.008549830	.024441900	0.000000000	.016667800	.012920900	.019210600
.006856610	.018225100	.018225100	.006856610	.019210600	.012920900
.016667800	0.000000000	.042831100	.042831100	0.000000000	.055238700
.034951700	.034951700	.055238700	0.000000000	.042831100	.034951700
.039195600	.039195600	.034951700	.042831100		

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TABLE 3-5 (CONTINUED)

124 ANGLES . 1,17.5,49 DEGREES ON A LEVEL
109 ANGLES IN THE &ETA DIRECTION, 15 ANGLES IN THE -ETA DIRECTION

8U

-.361249000	-.238619000	.238619000	-.750201000	-.661209000	-.238619000
.238619000	.661209000	-.971113000	-.932470000	-.661209000	-.238619000
.238619000	.661209000	.932470000	-.024917777	-.024913982	-.023764506
-.012458888	.012458888	.023764506	.024913982	-.057171433	-.057162725
-.054525365	-.028585716	.028585716	.054525365	.057162725	-.089555393
-.089541753	-.085410496	-.044777696	.044777696	.085410496	.089541753
-.121887680	-.121869116	-.116246347	-.060943840	.060943840	.116246347
.121869116	-.154107249	-.154083777	-.146974695	-.077053624	.077053624
.146974695	.154083777	-.186171501	-.186143147	-.177554917	-.093085751
.093085751	.177554917	.186143147	-.218042951	-.218009742	-.207951259
-.109021476	.109021476	.207951259	.218009742	-.249686111	-.249648083
-.238129877	-.124843056	.124843056	.238129877	.249648083	-.281066512
-.281023704	-.268057897	-.140533256	.140533256	.268057897	.281023704
-.312150340	-.312102798	-.297703070	-.156075170	.156075170	.297703070
.312102798	-.342904308	-.342852082	-.327033651	-.171452154	.171452154
.327033651	.342852082	-.501663000	-.433395000	-.148874000	.148874000
.433395000	-.733759000	-.679410000	-.433395000	-.148874000	.148874000
.433395000	.679410000	-.907204000	-.865063000	-.679410000	-.433395000
-.148874000	.148874000	.433395000	.679410000	.865063000	-.988856000
-.973907000	-.865063000	-.679410000	-.433395000	-.148874000	.148874000
.433395000	.679410000	.865063000	.973907000		
-.932470000	-.932470000	-.932470000	-.661209000	-.661209000	-.661209000
-.661209000	-.661209000	-.238619000	-.238619000	-.238619000	-.238619000
-.238619000	-.238619000	-.238619000	.999689504	.999689504	.999689504
.999689504	.999689504	.999689504	.999689504	.998364376	.998364376
.998364376	.998364376	.998364376	.998364376	.998364376	.995981843
.995981843	.995981843	.995981843	.995981843	.995981843	.995981843
.992543900	.992543900	.992543900	.992543900	.992543900	.992543900
.992543900	.988054126	.988054126	.988054126	.988054126	.988054126
.988054126	.988054126	.982517263	.982517263	.982517263	.982517263
.982517263	.982517263	.982517263	.975939174	.975939174	.975939174
.975939174	.975939174	.975939174	.975939174	.968326828	.968326828
.968326828	.968326828	.968326828	.968326828	.968326828	.959688291
.959688291	.959688291	.959688291	.959688291	.959688291	.959688291
.950032718	.950032718	.950032718	.950032718	.950032718	.950032718
.950032718	.939370340	.939370340	.939370340	.939370340	.939370340
.939370340	.939370340	.865063000	.865063000	.865063000	.865063000
.865063000	.679410000	.679410000	.679410000	.679410000	.679410000
.679410000	.679410000	.433395000	.433395000	.433395000	.433395000
.433395000	.433395000	.433395000	.433395000	.433395000	.148874000
.148874000	.148874000	.148874000	.148874000	.148874000	.148874000
.148874000	.148874000	.148874000	.148874000		

0.000000000	.042831100	.042831100	0.000000000	.055238700	.034951700
.034951700	.055238700	0.000000000	.042831100	.034951700	.039195600
.039195600	.034951700	.042831100	0.000000000	.000004427	.000061973
.000132799	.000132799	.000061973	.000004427	0.000000000	.000010300
.000144197	.000308994	.000308994	.000144197	.000010300	0.000000000
.000016171	.000226390	.000485122	.000485122	.000226390	.000016171
0.000000000	.000022025	.000308354	.000660759	.000660759	.000308354
.000022025	0.000000000	.000027857	.000389994	.000835700	.000835700
.000389994	.000027857	0.000000000	.000033659	.000471220	.001009758
.001009758	.000471220	.000033659	0.000000000	.000039425	.000551948
.001182745	.001182745	.000551948	.000039425	0.000000000	.000045149
.000632090	.001354479	.001354479	.000632090	.000045149	0.000000000
.000050826	.000711563	.001524778	.001524778	.000711563	.000050826
0.000000000	.000056449	.000790282	.001693462	.001693462	.000790282
.000056449	0.000000000	.000064109	.000897526	.001923271	.001923271
.000897526	.000064109	0.000000000	.024441900	.012920900	.012920900

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TABLE 3-5 (CONTINUED)

.024441900	0.000000000	.027011100	.008549830	.019210600	.019210600
.008549830	.027011100	0.000000000	.024441900	.008549830	.027468300
.006856610	.006856610	.027468300	.008549830	.024441900	0.000000000
.016667800	.012920900	.019210600	.006856610	.018225100	.018225100
.006856610	.019210600	.012920900	.016667800		

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TABLE 3-5 (CONTINUED)

124 ANGLES 2.5,17.5,49 DEGREES ON A LEVEL
15 ANGLES IN THE &ETA DIRECTION, 109 ANGLES IN THE -ETA DIRECTION

8U

-.024917777	-.024894060	-.023764506	-.012458888	.012458888	.023764506
.024894060	-.057171433	-.057117018	-.054525365	-.028585716	.028585716
.054525365	.057117018	-.089555393	-.089470156	-.085410496	-.044777696
.044777696	.085410496	.089470156	-.121887680	-.121771670	-.116246347
-.060943840	.060943840	.116246347	.121771670	-.154107249	-.153960573
-.146974695	-.077053624	.077053624	.146974695	.153960573	-.186171501
-.185994307	-.177554917	-.093085751	.093085751	.177554917	.185994307
-.218042951	-.217835423	-.207951259	-.109021476	.109021476	.207951259
.217835423	-.249686111	-.249448465	-.238129877	-.124843056	.124843056
.238129877	.249448465	-.281066512	-.280798999	-.268057897	-.140533256
.140533256	.268057897	.280798999	-.312150340	-.311853242	-.297703070
-.156075170	.156075170	.297703070	.311853242	-.342904308	-.342577939
-.327033651	-.171452154	.171452154	.327033651	.342577939	-.501663000
-.433395000	-.148874000	.148874000	.433395000	-.733759000	-.679410000
-.433395000	-.148874000	.148874000	.433395000	.679410000	-.901204000
-.865063000	-.679410000	-.433395000	-.148874000	.148874000	.433395000
.679410000	.865063000	-.988856000	-.973907000	-.865063000	-.679410000
-.433395000	-.148874000	.148874000	.433395000	.679410000	.865063000
.973907000	-.361249000	-.238619000	.238619000	-.750201000	-.661209000
-.238619000	.238619000	.661209000	-.971113000	-.932470000	-.661209000
-.238619000	.238619000	.661209000	.932470000		
-.999689504	-.999689504	-.999689504	-.999689504	-.999689504	-.999689504
-.999689504	-.998364376	-.998364376	-.998364376	-.998364376	-.998364376
-.998364376	-.998364376	-.995981843	-.995981843	-.995981843	-.995981843
-.995981843	-.995981843	-.995981843	-.992543900	-.992543900	-.992543900
-.992543900	-.992543900	-.992543900	-.992543900	-.988054126	-.988054126
-.988054126	-.988054126	-.988054126	-.988054126	-.988054126	-.982517263
-.982517263	-.982517263	-.982517263	-.982517263	-.982517263	-.982517263
-.975939174	-.975939174	-.975939174	-.975939174	-.975939174	-.975939174
-.975939174	-.968326828	-.968326828	-.968326828	-.968326828	-.968326828
-.968326828	-.968326828	-.959688291	-.959688291	-.959688291	-.959688291
-.959688291	-.959688291	-.959688291	-.950032718	-.950032718	-.950032718
-.950032718	-.950032718	-.950032718	-.950032718	-.939370340	-.939370340
-.939370340	-.939370340	-.939370340	-.939370340	-.939370340	-.865063000
-.865063000	-.865063000	-.865063000	-.865063000	-.679410000	-.679410000
-.679410000	-.679410000	-.679410000	-.679410000	-.679410000	-.433395000
-.433395000	-.433395000	-.433395000	-.433395000	-.433395000	-.433395000
-.433395000	-.433395000	-.148874000	-.148874000	-.148874000	-.148874000
-.148874000	-.148874000	-.148874000	-.148874000	-.148874000	-.148874000
-.148874000	.932470000	.932470000	.932470000	.661209000	.661209000
.661209000	.661209000	.661209000	.238619000	.238619000	.238619000
.238619000	.238619000	.238619000	.238619000		

0.000000000	.000011067	.000055333	.000132799	.000132799	.000055333
.000011067	0.000000000	.000025749	.000128747	.000308994	.000308994
.000128747	.000025749	0.000000000	.000040427	.000202134	.000485122
.000485122	.000202134	.000040427	0.000000000	.000055063	.000275316
.000660759	.000660759	.000275316	.000055063	0.000000000	.000069642
.000348209	.000835700	.000835700	.000348209	.000069642	0.000000000
.000084146	.000420732	.001009758	.001009758	.000420732	.000084146
0.000000000	.000098562	.000492810	.001182745	.001182745	.000492810
.000098562	0.000000000	.000112873	.000564366	.001354479	.001354479
.000564366	.000112873	0.000000000	.000127065	.000635324	.001524778
.001524778	.000635324	.000127065	0.000000000	.000141122	.000705609
.001693462	.001693462	.000705609	.000141122	0.000000000	.000160273
.000801363	.001923271	.001923271	.000801363	.000160273	0.000000000
.024441900	.012920900	.012920900	.024441900	0.000000000	.027011100
.008549830	.019210600	.019210600	.008549830	.027011100	0.000000000

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TABLE 3-5 (CONTINUED)

.024441900	.008549830	.027468300	.006856610	.006856610	.027468300
.008549830	.024441900	0.000000000	.016667800	.012920900	.019210600
.006856610	.018225100	.018225100	.006856610	.019210600	.012920900
.016667800	0.000000000	.042831100	.042831100	0.000000000	.055238700
.034951700	.034951700	.055238700	0.000000000	.042831100	.034951700
.039195600	.039195600	.034951700	.042831100		

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TABLE 3-5 (CONTINUED)

124 ANGLES 2.5,17.5,49 DEGREES ON A LEVEL
109 ANGLES IN THE &ETA DIRECTION, 15 ANGLES IN THE -ETA DIRECTION

8U

-.361249000	-.238619000	.238619000	-.750201000	-.661209000	-.238619000
.238619000	.661209000	-.971113000	-.932470000	-.661209000	-.238619000
.238619000	.661209000	.932470000	-.024917777	-.024894060	-.023764506
-.012458888	.012458888	.023764506	.024894060	-.057171433	-.057117018
-.054525365	-.028585716	.028585716	.054525365	.057117018	-.089555393
-.089470156	-.085410496	-.044777696	.044777696	.085410496	.089470156
-.121887680	-.121771670	-.116246347	-.060943840	.060943840	.116246347
.121771670	-.154107249	-.153960573	-.146974695	-.077053624	.077053624
.146974695	.153960573	-.186171501	-.185994307	-.177554917	-.093085751
.093085751	.177554917	.185994307	-.218042951	-.217835423	-.207951259
-.109021476	.109021476	.207951259	.217835423	-.249686111	-.249448465
-.238129877	-.124843056	.124843056	.238129877	.249448465	-.281066512
-.280798999	-.268057897	-.140533256	.140533256	.268057897	.280798999
-.312150340	-.311853242	-.297703070	-.156075170	.156075170	.297703070
.311853242	-.342904308	-.342577939	-.327033651	-.171452154	.171452154
.327033651	.342577939	-.501663000	-.433395000	-.148874000	.148874000
.433395000	-.733759000	-.679410000	-.433395000	-.148874000	.148874000
.433395000	.679410000	-.901204000	-.865063000	-.679410000	-.433395000
-.148874000	.148874000	.433395000	.679410000	.865063000	-.988856000
-.973907000	-.865063000	-.679410000	-.433395000	-.148874000	.148874000
.433395000	.679410000	.865063000	.973907000		
-.932470000	-.932470000	-.932470000	-.661209000	-.661209000	-.661209000
-.661209000	-.661209000	-.238619000	-.238619000	-.238619000	-.238619000
-.238619000	-.238619000	-.238619000	.999689504	.999689504	.999689504
.999689504	.999689504	.999689504	.999689504	.998364376	.998364376
.998364376	.998364376	.998364376	.998364376	.998364376	.995981843
.995981843	.995981843	.995981843	.995981843	.995981843	.995981843
.992543900	.992543900	.992543900	.992543900	.992543900	.992543900
.992543900	.988054126	.988054126	.988054126	.988054126	.988054126
.988054126	.988054126	.982517263	.982517263	.982517263	.982517263
.982517263	.982517263	.982517263	.975939174	.975939174	.975939174
.975939174	.975939174	.975939174	.975939174	.968326828	.968326828
.968326828	.968326828	.968326828	.968326828	.968326828	.959688291
.959688291	.959688291	.959688291	.959688291	.959688291	.959688291
.950032718	.950032718	.950032718	.950032718	.950032718	.950032718
.950032718	.939370340	.939370340	.939370340	.939370340	.939370340
.939370340	.939370340	.865063000	.865063000	.865063000	.865063000
.865063000	.679410000	.679410000	.679410000	.679410000	.679410000
.679410000	.679410000	.433395000	.433395000	.433395000	.433395000
.433395000	.433395000	.433395000	.433395000	.433395000	.148874000
.148874000	.148874000	.148874000	.148874000	.148874000	.148874000
.148874000	.148874000	.148874000	.148874000		

0.000000000	.042831100	.042831100	0.000000000	.055238700	.034951700
.034951700	.055238700	0.000000000	.042831100	.034951700	.039195600
.039195600	.034951700	.042831100	0.000000000	.000011067	.000055333
.000132799	.000132799	.000055333	.000011067	0.000000000	.000025749
.000128747	.000308994	.000308994	.000128747	.000025749	0.000000000
.000040427	.000202134	.000485122	.000485122	.000202134	.000040427
0.000000000	.000055063	.000275316	.000660759	.000660759	.000275316
.000055063	0.000000000	.000069642	.000348209	.000835700	.000835700
.000348209	.000069642	0.000000000	.000084146	.000420732	.001009758
.001009758	.000420732	.000084146	0.000000000	.000098562	.000492810
.001182745	.001182745	.000492810	.000098562	0.000000000	.000112873
.000564366	.001354479	.001354479	.000564366	.000112873	0.000000000
.000127065	.000635324	.001524778	.001524778	.000635324	.000127065
0.000000000	.000141122	.000705609	.001693462	.001693462	.000705609
.000141122	0.000000000	.000160273	.000801363	.001923271	.001923271

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TABLE 3-5 (CONTINUED)

.000801363	.000160273	0.000000000	.024441900	.012920900	.012920900
.024441900	0.000000000	.027011100	.008549830	.019210600	.019210600
.008549830	.027011100	0.000000000	.024441900	.008549830	.027468300
.006856610	.006856610	.027468300	.008549830	.024441900	0.000000000
.016667800	.012920900	.019210600	.006856610	.018225100	.018225100
.006856610	.019210600	.012920900	.016667800		

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TABLE 3-5 (CONTINUED)

146 ANGLES　　　　1,6,30,70 DEGREES ON A LEVEL
15 ANGLES IN THE &ETA DIRECTION, 131 ANGLES IN THE -ETA DIRECTION

8U

-.024917777	-.024913982	-.024781274	-.021579428	-.008522382	.008522382
.021579428	.024781274	.024913982	-.057171433	-.057162725	-.056858242
-.049511913	-.019553782	.019553782	.049511913	.056858242	.057162725
-.089555393	-.089541753	-.089064799	-.077557245	-.030629748	.030629748
.077557245	.089064799	.089541753	-.121887680	-.121869116	-.121219967
-.105557827	-.041688042	.041688042	.105557827	.121219967	.121869116
-.154107249	-.154083777	-.153263033	-.133460792	-.052707783	.052707783
.133460792	.153263033	.154083777	-.186171501	-.186143147	-.185151634
-.161229250	-.063674404	.063674404	.161229250	.185151634	.186143147
-.218042951	-.218009742	-.216848489	-.188830735	-.074575081	.074575081
.188830735	.216848489	.218009742	-.249686111	-.249648083	-.248318305
-.216234515	-.085397680	.085397680	.216234515	.248318305	.249648083
-.281066512	-.281023704	-.279526800	-.243410739	-.096130409	.096130409
.243410739	.279526800	.281023704	-.312150340	-.312102798	-.310440348
-.270330124	-.106761704	.106761704	.270330124	.310440348	.312102798
-.342904308	-.342852082	-.341025842	-.296963842	-.117280181	.117280181
.296963842	.341025842	.342852082	-.501663000	-.433395000	-.148874000
.148874000	.433395000	-.733759000	-.679410000	-.433395000	-.148874000
.148874000	.433395000	.679410000	-.901204000	-.865063000	-.679410000
-.433395000	-.148874000	.148874000	.433395000	.679410000	.865063000
-.988856000	-.973907000	-.865063000	-.679410000	-.433395000	-.148874000
.148874000	.433395000	.679410000	.865063000	.973907000	-.361249000
-.238619000	.238619000	-.750201000	-.661209000	-.238619000	.238619000
.661209000	-.971113000	-.932470000	-.661209000	-.238619000	.238619000
.661209000	.932470000				
-.999689504	-.999689504	-.999689504	-.999689504	-.999689504	-.999689504
-.999689504	-.999689504	-.999689504	-.998364376	-.998364376	-.998364376
-.998364376	-.998364376	-.998364376	-.998364376	-.998364376	-.998364376
-.995981843	-.995981843	-.995981843	-.995981843	-.995981843	-.995981843
-.995981843	-.995981843	-.995981843	-.992543900	-.992543900	-.992543900
-.992543900	-.992543900	-.992543900	-.992543900	-.992543900	-.992543900
-.988054126	-.988054126	-.988054126	-.988054126	-.988054126	-.988054126
-.988054126	-.988054126	-.988054126	-.982517263	-.982517263	-.982517263
-.982517263	-.982517263	-.982517263	-.982517263	-.982517263	-.982517263
-.975939174	-.975939174	-.975939174	-.975939174	-.975939174	-.975939174
-.975939174	-.975939174	-.975939174	-.968326828	-.968326828	-.968326828
-.968326828	-.968326828	-.968326828	-.968326828	-.968326828	-.968326828
-.959688291	-.959688291	-.959688291	-.959688291	-.959688291	-.959688291
-.959688291	-.959688291	-.959688291	-.950032718	-.950032718	-.950032718
-.950032718	-.950032718	-.950032718	-.950032718	-.950032718	-.950032718
-.939370340	-.939370340	-.939370340	-.939370340	-.939370340	-.939370340
-.939370340	-.939370340	-.939370340	-.865063000	-.865063000	-.865063000
-.865063000	-.865063000	-.679410000	-.679410000	-.679410000	-.679410000
-.679410000	-.679410000	-.679410000	-.433395000	-.433395000	-.433395000
-.433395000	-.433395000	-.433395000	-.433395000	-.433395000	-.433395000
-.148874000	-.148874000	-.148874000	-.148874000	-.148874000	-.148874000
-.148874000	-.148874000	-.148874000	-.148874000	-.148874000	.932470000
.932470000	.932470000	.661209000	.661209000	.661209000	.661209000
.661209000	.238619000	.238619000	.238619000	.238619000	.238619000
.238619000	.238619000				
0.000000000	.000004427	.000017706	.000088532	.000088532	.000088532
.000088532	.000017706	.000004427	0.000000000	.000010300	.000041199
.000205996	.000205996	.000205996	.000205996	.000041199	.000010300
0.000000000	.000016171	.000064683	.000323415	.000323415	.000323415
.000323415	.000064683	.000016171	0.000000000	.000022025	.000088101
.000440506	.000440506	.000440506	.000440506	.000088101	.000022025
0.000000000	.000027857	.000111427	.000557134	.000557134	.000557134
.000557134	.000111427	.000027857	0.000000000	.000033659	.000134634

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TABLE 3-5 (CONTINUED)

.000673172	.000673172	.000673172	.000673172	.000134634	.000033659
0.000000000	.000039425	.000157699	.000788497	.000788497	.000788497
.000788497	.000157699	.000039425	0.000000000	.000045149	.000180597
.000902986	.000902986	.000902986	.000902986	.000180597	.000045149
0.000000000	.000050826	.000203304	.001016519	.001016519	.001016519
.001016519	.000203304	.000050826	0.000000000	.000056449	.000225795
.001128974	.001128974	.001128974	.001128974	.000225795	.000056449
0.000000000	.000064109	.000256436	.001282180	.001282180	.001282180
.001282180	.000256436	.000064109	0.000000000	.024441900	.012920900
.012920900	.024441900	0.000000000	.027011100	.008549830	.019210600
.019210600	.008549830	.027011100	0.000000000	.024441900	.008549830
.027468300	.006856610	.006856610	.027468300	.008549830	.024441900
0.000000000	.016667800	.012920900	.019210600	.006856610	.018225100
.018225100	.006856610	.019210600	.012920900	.016667800	0.000000000
.042831100	.042831100	0.000000000	.055238700	.034951700	.034951700
.055238700	0.000000000	.042831100	.034951700	.039195600	.039195600
.034951700	.042831100				

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TABLE 3-5 (CONTINUED)

146 ANGLES 1,6,30,70 DEGREES ON A LEVEL
131 ANGLES IN THE &ETA DIRECTION, 15 ANGLES IN THE -ETA DIRECTION

8U

-.361249000	-.238619000	.238619000	-.750201000	-.661209000	-.238619000
.238619000	.661209000	-.971113000	-.932470000	-.661209000	-.238619000
.238619000	.661209000	.932470000	-.024917777	-.024913982	-.024781274
-.021579428	-.008522382	.008522382	.021579428	.024781274	.024913982
-.057171433	-.057162725	-.056858242	-.049511913	-.019553782	.019553782
.049511913	.056858242	.057162725	-.089555393	-.089541753	-.089064799
-.077557245	-.030629748	.030629748	.077557245	.089064799	.089541753
-.121887680	-.121869116	-.121219967	-.105557827	-.041688042	.041688042
.105557827	.121219967	.121869116	-.154107249	-.154083777	-.153263033
-.133460792	-.052707783	.052707783	.133460792	.153263033	.154083777
-.186171501	-.186143147	-.185151634	-.161229250	-.063674404	.063674404
.161229250	.185151634	.186143147	-.218042951	-.218009742	-.216848489
-.188830735	-.074575081	.074575081	.188830735	.216848489	.218009742
-.249686111	-.249648083	-.248318305	-.216234515	-.085397680	.085397680
.216234515	.248318305	.249648083	-.281066512	-.281023704	-.279526800
-.243410739	-.096130409	.096130409	.243410739	.279526800	.281023704
-.312150340	-.312102798	-.310440348	-.270330124	-.106761704	.106761704
.270330124	.310440348	.312102798	-.342904308	-.342852082	-.341025842
-.296963842	-.117280181	.117280181	.296963842	.341025842	.342852082
-.501663000	-.433395000	-.148874000	.148874000	.433395000	-.733759000
-.679410000	-.433395000	-.148874000	.148874000	.433395000	.679410000
-.901204000	-.865063000	-.679410000	-.433395000	-.148874000	.148874000
.433395000	.679410000	.865063000	-.988856000	-.973907000	-.865063000
-.679410000	-.433395000	-.148874000	.148874000	.433395000	.679410000
.865063000	.973907000				
-.932470000	-.932470000	-.932470000	-.661209000	-.661209000	-.661209000
-.661209000	-.661209000	-.238619000	-.238619000	-.238619000	-.238619000
-.238619000	-.238619000	-.238619000	.999689504	.999689504	.999689504
.999689504	.999689504	.999689504	.999689504	.999689504	.999689504
.998364376	.998364376	.998364376	.998364376	.998364376	.998364376
.998364376	.998364376	.998364376	.995981843	.995981843	.995981843
.995981843	.995981843	.995981843	.995981843	.995981843	.995981843
.992543900	.992543900	.992543900	.992543900	.992543900	.992543900
.992543900	.992543900	.992543900	.988054126	.988054126	.988054126
.988054126	.988054126	.988054126	.988054126	.988054126	.988054126
.982517263	.982517263	.982517263	.982517263	.982517263	.982517263
.982517263	.982517263	.982517263	.975939174	.975939174	.975939174
.975939174	.975939174	.975939174	.975939174	.975939174	.975939174
.968326828	.968326828	.968326828	.968326828	.968326828	.968326828
.968326828	.968326828	.968326828	.959688291	.959688291	.959688291
.959688291	.959688291	.959688291	.959688291	.959688291	.959688291
.950032718	.950032718	.950032718	.950032718	.950032718	.950032718
.950032718	.950032718	.950032718	.939370340	.939370340	.939370340
.939370340	.939370340	.939370340	.939370340	.939370340	.939370340
.865063000	.865063000	.865063000	.865063000	.865063000	.679410000
.679410000	.679410000	.679410000	.679410000	.679410000	.679410000
.433395000	.433395000	.433395000	.433395000	.433395000	.433395000
.433395000	.433395000	.433395000	.148874000	.148874000	.148874000
.148874000	.148874000	.148874000	.148874000	.148874000	.148874000
.148874000	.148874000				

0.000000000	.042831100	.042831100	0.000000000	.055238700	.034951700
.034951700	.055238700	0.000000000	.042831100	.034951700	.039195600
.039195600	.034951700	.042831100	0.000000000	.000004427	.000017706
.000088532	.000088532	.000088532	.000088532	.000017706	.000004427
0.000000000	.000010300	.000041199	.000205996	.000205996	.000205996
.000205996	.000041199	.000010300	0.000000000	.000016171	.000064683
.000323415	.000323415	.000323415	.000323415	.000064683	.000016171

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TABLE 3-5 (CONTINUED)

0.000000000	.000022025	.000088101	.000440506	.000440506	.000440506
.000440506	.000088101	.000022025	0.000000000	.000027857	.000111427
.000557134	.000557134	.000557134	.000557134	.000111427	.000027857
0.000000000	.000033659	.000134634	.000673172	.000673172	.000673172
.000673172	.000134634	.000033659	0.000000000	.000039425	.000157699
.000788497	.000788497	.000788497	.000788497	.000157699	.000039425
0.000000000	.000045149	.000180597	.000902986	.000902986	.000902986
.000902986	.000180597	.000045149	0.000000000	.000050826	.000203304
.001016519	.001016519	.001016519	.001016519	.000203304	.000050826
0.000000000	.000056449	.000225795	.001128974	.001128974	.001128974
.001128974	.000225795	.000056449	0.000000000	.000064109	.000256436
.001282180	.001282180	.001282180	.001282180	.000256436	.000064109
0.000000000	.024441900	.012920900	.012920900	.024441900	0.000000000
.027011100	.008549830	.019210600	.019210600	.008549830	.027011100
0.000000000	.024441900	.008549830	.027468300	.006856610	.006856610
.027468300	.008549830	.024441900	0.000000000	.016667800	.012920900
.019210600	.006856610	.018225100	.018225100	.006856610	.019210600
.012920900	.016667800				

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TABLE 3-6

QUADRATURE DATA SET PARAMETERS

Symmetric Quadrature Sets

Number of Quadrature Angles (NQI or NQJ)	Number of Quadrature Angles in the upward (+η) direction (NQIU or NQJU)	Number of Quadrature Angles in the downward (−η) direction	Number of Initialization directions in the upward (+η) direction	Number of Initialization directions in the downward (−η) direction
6 (S_2)	3	3	1	1
16 (S_4)	8	8	2	2
30 (S_6)	15	15	3	3
48 (S_8)	24	24	4	4
96 (S_{12})	48	48	6	6
160 (S_{16})	80	80	8	8

Asymmetric Quadrature Sets

Number of Quadrature Angles (NQI or NQJ)	Number of Quadrature Angles in the upward (+η) direction (NQIU or NQJU)	Number of Quadrature Angles in the downward (−η) direction	Number of Initialization directions in the upward (+η) direction	Number of Initialization directions in the downward (−η) direction
80 (−η asymmetry)	15	65	3	15
80 (+η asymmetry)	65	15	15	3
102 (−η asymmetry)	15	87	3	15
102 (+η asymmetry)	87	15	15	3
124 (−η asymmetry)	15	109	3	15
124 (+η asymmetry	109	15	15	3
138 (−η asymmetry)	15	123	3	17
138 (+η asymmetry)	123	15	17	3
146 (−η asymmetry	15	131	3	15
146 (+η asymmetry)	131	15	15	3

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4.0 DETAILED INPUT DATA INFORMATION

The input data requirements for the MAP code have been described in Section 3.0. In a number of areas, input data preparation guidelines in setting up problems have been established. As a result, this section presents an expanded description of specific input data to assist the user in problem setup.

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4.1 AZIMUTHAL MESH SPACING

The numerical integration over the source surface in a MAP calculation requires an adequate azimuthal mesh spacing to obtain an accurate solution while conserving available core memory data storage and computer time. This azimuthal mesh spacing is dependent upon the extent of the visible surface, the location of the detector point, the anisotropy of the leakage angular flux, and the discrete ordinate angular quadrature at the source surface. A few simple rules which will provide a good solution under normal circumstances are as follows:

1. An upper limit of the azimuthal mesh spacing, $\Delta\theta$, is determined by the angular quadrature at the source surface. Generally, the number of mesh intervals should be twice the angular quadrature order for symmetric quadrature sets, or twice the number of azimuthal angles in any one of the polar angle (η) levels. This criteria is defined for the top or bottom and side surfaces as follows:

<u>Top or Bottom Surface:</u>

$$\Delta\theta_m = \theta_{m+1} - \theta_m \leq \frac{180^\circ}{2 \cdot N}$$

Side Surfaces:

$$\Delta\theta_m = \theta_{m+1} - \theta_m \leq \frac{90^\circ}{2 \cdot N}$$

Where:

θ_{m+1} and θ_m	are MAP input (CTQ or CSQ arrays)
N	is the symmetric quadrature order (i.e. 4 for S_4) or the maximum number of angles in any η level.

This criteria is based on the MAP procedure of rotating the angular flux unit sphere through 180° during integration at the top or bottom surface or through a maximum of 90° at the side surface.

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This arbitrary criteria is also based on the use of each angle in each η level at least once in the MAP surface azimuthal angle integration.

2. A lower limit to the number of azimuthal mesh intervals is based on the source surface mesh interval widths Δr, or Δz. The length of a surface mesh cell, $\Delta \theta_m r_s$ or $\Delta \theta_m \bar{r}_i$, should generally be of the same approximate size as the other dimension of the surface mesh cell, Δz or Δr.

The above criteria can be applied to all calculations involving detector points located at large distances from the source surface. More stringent criteria must be placed on azimuthal mesh spacing when a detector point is in close proximity to the source surface where the mesh spacing is of the same size as the distance from the source surface to the detector point.

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4.2 ANGULAR FLUX INTERPOLATION

The use of angular flux interpolation to calculate the angular dependent source is limited to use with discrete ordinate quadratures which are symmetric about the z axis and are defined by the standard S_n discrete direction pattern. In addition, the angular flux interpolation technique, i.e., interpolation in the polar angle (η), is based on Gauss mechanical quadrature ordinates and weights. Therefore, data based on Gauss mechanical quadrature are the recommended discrete ordinate quadrature data for MAP. The input surface angular fluxes from DOT-IIW should be for the same quadrature. Experience has shown that other quadrature data (e.g., Lathrop's completely symmetric data) can be used in calculating the surface angular fluxes required for MAP input without any observed loss of accuracy, but the user is cautioned in the use of any data other than that based on Gauss mechanical quadrature ordinates. Recommended quadrature data are listed in Section 3.4.

One additional limitation in the use of interpolation is the requirement for a large amount of core memory storage and computer time. The increased storage segment is discussed in Section 3.3 and computer time requirements are discussed in Section 5.2.

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4.3 DETECTOR SURFACE GEOMETRY

A detector surface in the MAP code is defined by a series of point detectors which lie on the detector surface. The MAP code uses the DOT-IIW angular fluxes from an r, z problem and the conditions of symmetry at the r, z surface require only that a detector surface be defined as the intersection of the detector surface and the r, z plane of the DOT-IIW solution. Each type of detector surface is described below.

Plane Detector Surface, NTSUR=1

The plane detector surface which is normal to the z axis is represented as the line of intersection of a disk and the r, z plane at a constant z. This line is represented as a series of mesh intervals (mesh line input identical to DOT-IIW) each represented by a point detector at the midpoint of the interval. Input data for this option are the r's (17* or 17 array) of the mesh lines, $R2_m$, and the z of the surface, ZR, which is used to define the coordinates of the detector point as:

$$\overline{R}_m = \frac{R2_{m+1} + R2_m}{2.0}$$

$$\overline{Z}_m = ZR$$

Meridian Ring-Spherical Detector Surface, NTSUR=2

A spherical detector surface is defined as the line of intersection of a sphere and the r, z plane. This line, which is a circle (meridian ring) is represented as a series of arc length intervals each represented by a point detector at the midpoint of the arc. The input to MAP is the cosine of the polar angles which define the limits of the arc length intervals; the point detector is at the midpoint of the polar angles defining the arc length.

Input data for this option are the cosines of the polar angle mesh lines, $R2_m$, the radius of the detector surface, RZ, and its origin, ZM. These data are used to define the

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coordinates of the detector points as:

$$\overline{R}_m = RZ \cdot \sin\left(\frac{\alpha_{m+1} + \alpha_m}{2.0}\right)$$

$$\overline{Z}_m = RZ \cdot \cos\left(\frac{\alpha_{m+1} + \alpha_m}{2.0}\right) + ZM$$

where: $\alpha_m = \cos^{-1}(R2_m)$

Cylindrical Detector Surface, NTSUR=3

The cylindrical detector surface which is parallel to the axis of the r, z geometry and concentric with the r, z source surface is represented as the line of intersection of the cylindrical surface and the r, z solution plane. This line is represented as a series of mesh intervals (mesh line input identical to DOT-IIW) each represented by a point detector at the midpoint of the interval. Input data for this option are the z's (17* or 17 array) of the mesh lines, $R2_m$, and the radius of the surface, RL, which will be used to define the coordinates of the detector points as:

$$\overline{R}_m = RL,$$

$$\overline{Z}_m = \frac{R2_{m+1} + R2_m}{2.0}$$

General Detector Surface, NTSUR=4

A general detector surface is defined in the MAP input as the coordinate R_m's and Z_m's of detector points. These data, RJ_m and ZJ_m are entered in the 13* and 14* arrays for each detector point.

In the MAP code the calculation of the angular flux at a detector point is dependent on the orientation of the detector surface; however, the MAP code does calculate the current at each detector point based on the detector point located on a plane normal to the z axis, except when a cylindrical surface (when NTSUR=3) is used. In this case the outward directed current is calculated.

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4.4 TAGGED SURFACES

In the final edit of the MAP calculated data at the detector surface the calculation of the contributions from specified sets of surface mesh cells are provided. This selective source surface option allows the user to analyze the effect of portions of surface leakage on detector response. Input requirements to use this option consist of a pair of mesh interval numbers (5 $ and 6 $ array) for the side surface or for the top (bottom) surface. The contribution to the detector point flux from each surface mesh cell within the range of each pair of mesh interval numbers is the tagged surface total.

4.5 RESPONSE FUNCTIONS

A desirable feature of the MAP code is the ability to apply multigroup conversion factors to the energy dependent neutron or photon scalar flux, at each detector point. For example, application of the conversion factors to the photon detector flux could, at the option of the user, provide photon detector response data in units of: Mev/cm^2-sec, R/hr, R/hr-watt, Rads (-carbon)/hr, watts/gm-aluminum, etc., all in a single MAP problem.

The MAP code calculates the total flux at a given detector point from all source surfaces (including tagged surfaces) as the sum over the contributing surface mesh cells in the source surface defined (total, top, bottom, side, or tagged).

A set of input data for each group of the multigroup set and for each type of detector response is entered in the 12* or 12U array. These data are then multiplied by the sets of detector multigroup flux results and summed over energy group for each type of source surface to provide the detector point response. The user can input as many responses as desired with ability to provide titles for each set of detector data provided in the input using the 11 H array.

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4.6 NORMALIZATION

In order to provide results which are normalized to absolute or unit power levels, a single input value of a normalization factor is provided in the input data to MAP. This value, SCALE, is a constant multiplier of all MAP calculated flux data and response data. If SCALE is input as zero, (0.0), MAP sets SCALE to a value of one, (1.0). The normalization factor of the MAP code is dependent upon the units of the surface angular fluxes of the DOT-IIW code problem. The user is referred to Section 3.7.4 of Reference 1 for the definition of the DOT-IIW normalization.

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4.7 ZONES AND BOUNDARY SURFACES

The required input geometry data for the MAP code are described in DATA SET 4 of Section 3.2. The use of these data in the MAP calculation is described in Section 7.1. In the setup of the geometry, the user describes a set of intersecting quadratic surfaces. These quadratic surfaces can take the form of the general quadratic equation (without cross product terms) or one of the degenerate forms. These equation types, (NBE, 4 $ array), are tabulated in Table 3-2. The user is provided the option to input either the square of the coefficient D (11* or U array), or the coefficient D. This option is provided as the optional equation types 7, 8, or 9. The MAP code calculates D^2 and changes the equation type to the input value, NBE, minus 6. Caution must be exercised in change cases, so that if a boundary of type 7, 8, or 9 changes, then both NBE and D must be input for the change case.

With the defined quadratic surfaces the user specifies the boundary surfaces for each zone, (NBD, 2 $ array), of a problem. The MAP geometry capability is limited to 6 boundary surfaces per zone. The input of boundary surfaces by zone are in multiples of six (one zone per card) with the surface numbers not required as input if zero (0). The zone-boundary surface relationship (i.e., the ambiguity index of + or -) is assigned internal to MAP from the MAP input data, (XPO, 16* or 16 U array), defined in Data Set 4 of Section 3.2. The user must input the coordinates of a point in each zone to define the proper zone location. In addition to the zone boundary surfaces, the most probable zone entered upon crossing each zone surface is entered in NTR (3 $ array). The only limitation is that the number of the zone entered must be greater that 1 and less than or equal to NZ. To minimize the ray trace geometry calculation time, the user should enter the zone entered and the most probable ray trace through the boundary or if more than one zone can be entered, then the zone with the smallest number should be used. This approach is suggested since the zone entered search is performed sequentially from NTR to NZ and from 1 to NTR-1. The material assigned to each zone is defined by the input value, (NMZ, 15 $ array).

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4.8 CROSS SECTIONS

The user has the capability to input macroscopic cross sections by group, SIG (17* or 17 U array), or the code will calculate data based on the GAMLEG-W[6] cross section tapes. The macroscopic cross section data are related to the zones by the NMZ array and these data must be in units of cm^{-1}. If the composition material-mixture material capability is used with the magnetic tape input, the MAP code calculates only photon cross sections as described in Section 7.2 for each material. These data are evaluated at energy points, (EG, 12* or 12 U array), for elements defined by their atomic numbers, (ZOE, 13* or 13 U array). These data are not multigroup data and care must be exercised in using these calculated cross sections with multigroup leakage data from DOT-IIW.

4.9 FLUX DATA

The MAP code accepts as input flux data from the r, z, source surface, the standard DOT-IIW (or DOT-II) output flux data tape. This data tape contains the multigroup data of scalar fluxes, higher flux moments, and side, top and bottom surface leakage angular fluxes. The magnetic tape format consists of a logical tape record for each group of the multigroup solution with the content of each record dependent upon the type of DOT-IIW (or DOT-II) solution. The contents of the output tape are described as follows:

1) The flux tape is written in the binary mode and contains one group of data for each logical record.
2) The first NRI* NZI (DOT-IIW input parameters IMxJM) words in each record contain the scalar flux data for each mesh cell in the order of all radial mesh data for axial interval 1, all radial mesh interval data for axial mesh interval 2, etc.
3) The next word (s) is dependent upon the scattering approximation used in the DOT-IIW (or DOT-II) problem. If the tape is written from a P_0 or transport corrected problem, (DOT-IIW input parameter A03=0) then the next word is a 0.0. If the tape is prepared in a P_ℓ problem (A03>0), then the next NRI*

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NZI* (A03* (A03 + 3))/2 words contain the flux moments. The terms are in the same order by mesh cell as the scalar flux data for each flux moment.

4) The next NQI* NZI (DOT-IIW input parameters A04* JM) words are the surface leakage angular fluxes at the left and right boundaries of the DOT-IIW problem geometry. These angular fluxes are used as input data and those data with positive direction cosines, $\mu>0.0$, are the cylindrical surface leakage fluxes.

5) The next NQI* NRI words are the surface leakage angular fluxes at the bottom and top of the DOT-IIW problem geometry. These angular fluxes are used as input data to MAP and the data with positive direction cosines, $\eta>0.0$, are the top surface data, and the data with negative direction cosines, $\eta<0.0$, are the bottom surface.

The MAP code input specifies the number of radial mesh intervals (NRI), axial mesh intervals (NZI), number of quadrature angles (NQI) and the scattering approximation (NPL). The scalar flux and flux moments data are read sequentially with core memory storage to minimize computer storage requirements for MAP. The presence or absence of higher flux moments is handled as two seperate tape reads.

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5.0 PROBLEM SETUP INFORMATION

The setup of a MAP code problem is described in this section with a specific sample problem setup and deck listing given in Section 5.4. This section is intended to define the deck setup on the WANL CDC 6600 computer system; the setup on other systems can be derived from this description. The CDC 6600 version of the code resides on a binary tape and is used in production by the loading of the binary code from tape for each problem using control cards. The use of tape or disk files, running time estimates, and error messages are described in the following sections.

5.1 TAPE OR DISK FILE ASSIGNMENTS

The MAP code requires a maximum of six magnetic tape or disk files. The specific number of files required is dependent upon the type of problem. In some instances the use of disk devices can be substituted for scratch tapes with a corresponding decrease in peripheral processor (PP) time and elapsed time. For the majority of problems, only two tapes are required; all other files can be disk devices. The file assignments for MAP are as follows:

Tape 3	Cross Section Library Input Tape/Required only if NBA=1/
Tape 4	Scratch-Group Dependent Geometry Data/Required only if NZ>0/
Tape 5	Input Disk
Tape 6	Printed Output Disk
Tape 7	Punched Output Disk
Tape 9	Output Angular Flux Tape/Required only if NPNH=2 or 3/
Tape 10	Scratch-Group Independent Geometry Data
Tape 11	Surface Angular Flux Input Tape (Output Scalar Flux Tape from DOT-IIW or DOT)
Tape 12	Scratch-Group Dependent Detector Response

To minimize the peripheral processor (PP) and elapsed time of MAP problems the user should use disk devices for Tapes 4 and 10 when geometry and/or angular flux interpolation is used because of the large volume of data to be transferred during the detector multigroup flux solution.

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5.2 RUNNING TIME

The required running time on the CDC 6600 computer for a given MAP problem is mainly dependent upon the number of source surface mesh cells, the number of detectors, the number of groups, and the use of the angular flux interpolation or geometry capabilities. An upper limit estimate of the central processor (CP) time required is obtained from the following equation:

$$\text{CP time (seconds)} = \frac{(\text{NMU* NRI} + \text{NMUS* NZI})\text{* NGN* NRJ* } 1.2}{S}$$

where: NRI and NZI are the number of radial and axial mesh intervals in the angular flux solution for DOT-IIW or the integration mesh (NRK and NZK)

NMU and NMUS are the number of azimuthal integration mesh intervals for the top (or bottom) or side source surfaces

NGN is the number of energy groups

NRJ is the number of detector points

S is a constant dependent upon the type of problem

The constant S in defined as follows:

Angular Flux Interpolation (NIT)	Geometry (NZ)	S
No	No	600
No	Yes	500
Yes	No	300
Yes	Yes	250

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5.3 ERROR MESSAGES

A number of MAP code generated error messages may be encountered in running a MAP problem. These messages are primarily due to the incorrect problem input. The error messages are generally self explanatory.

Message	Explanation
"This problem has an assigned data array of ______ locations (ISIZE), This problem requires a data array of ______ locations (LAST)"	Problem is too large to fit on the computer or else the value of ISIZE was input incorrectly.
"Error in FIDO JERR = ______"	An input error occurred in the FIDO input data. JERR arrays are in error and the FIDO routine prints the error prior to the reading of data arrays.
"Error in axial coordinates for interval ______, Z (I), Z (I + 1) = ______"	Non-increasing, axial coordinates Z (I + 1)< Z (I).
"Error in radii for interval ______, R (I), R (I + 1) = ______"	Non-increasing, radial coordinates R (I + 1)< R (I).
"Error in (DOT, for example) surface quadrature, MU = 0.0"	The direction cosines describing the μ quadrature coefficients are in error.
"Error in (DOT, for example) surface quadrature, ETA = 0.0"	The direction cosines describing the η quadrature coefficients are in error.
"Error in (DOT, for example) surface quadrature, SUM W (I). NE. 1.0"	The quadrature weights do not sum to 1.0 i.e., $\left\lvert \sum w_m - 1.0 \right\rvert > 1.0 \times 10^{-4}$
"Error in (DOT, for example) surface quadrature, SUM W (I). NE. 1.0"	Error in direction cosines and/or weights $\left\lvert \sum \mu_m \eta_m w_m \right\rvert . > 1.0 \times 10^{-4}$

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"Errors were found"	The MAP code performs all the quadrature checks, and prints out the total number of quadrature check errors if any occurred.
"Error, N entries required in (3*, for example) array, data edit continues "	Too many or too few pieces of data were input to the specified array.
"Warning, Interpolation used in the (9$, for example) integer array, data edit continues"	The code is warning the user that integer interpolation, which involves computer integer arithmetic is being used. Computers in performing integer arithmetic, drop any fractional remainder.
"Fill option ignored in (9$, for example) array"	The code already has all the data it needs for the specified array.
"Warning, Address ______ is beyond the limits of (9$, for example) array"	The user, in inputing data with the A format, has exceeded the storage area set aside for the specified array.
"Geometry error-zone ____, bnd ____, bnd no. ____, eg no. ____, coordinates x= ____, y= ____, z= ____ "	Input error in the ray tracing geometry section
"Geometry error zone ____, boundary ____, distance ____, coordinates (x, y, z) ____ "	Input error in the ray tracing geometry section.
"Interpolant out of range"	In interpolating the cross section data, the energy is beyond the range of the library data.

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5.4 SAMPLE PROBLEM INPUT

A set of sample problems has been included in this report to illustrate the flexibility of the input data formats and the problem deck setup. In addition, the DOT-IIW problem input deck listing (which generates the input magnetic tape for use in the MAP sample problem) is included so that a test of the MAP code is illustrated for the user.

The sample problem geometry is a cylindrical slab (i.e., r, z, geometry) of lead. This problem geometry is shown schematically in Figure 5-1. The external dimensions of the slab are 50-cm. in radius by 10.0-cm. thick. The DOT-IIW problem is a 25 radial by 5 axial mesh interval problem in which the radial and mesh interval are of equal size. The problem is a two group photon transport problem with a uniform fixed distributed source distributed radially in the fifth axial interval. An S_6 angular quadrature approximation and a P_1 Legendre polynomial scattering approximation is used. Quadrature data are from Table 3-1 and the P_5 photon transport cross section for the two groups are from GAMLEG-W.[6] The card listing of the DOT-IIW problem deck is given in Table 5-1. The output magnetic tape containing the scalar fluxes and surface leakage fluxes is obtained from tape unit 1 and is required input to the MAP sample problem.

The MAP sample problem for this geometry consists of the DOT-IIW cylindrical slab and a detector plane normal to the slab z axis. The detector plane is at a z of -487.5 centimeters from the slab lower surface, z = 0.0. A total of 37 radial mesh intervals are used to subdivide the detector surface. A card listing of the MAP code problem is given in Table 5-2. The printout of the MAP sample problem is given in Section 6.0.

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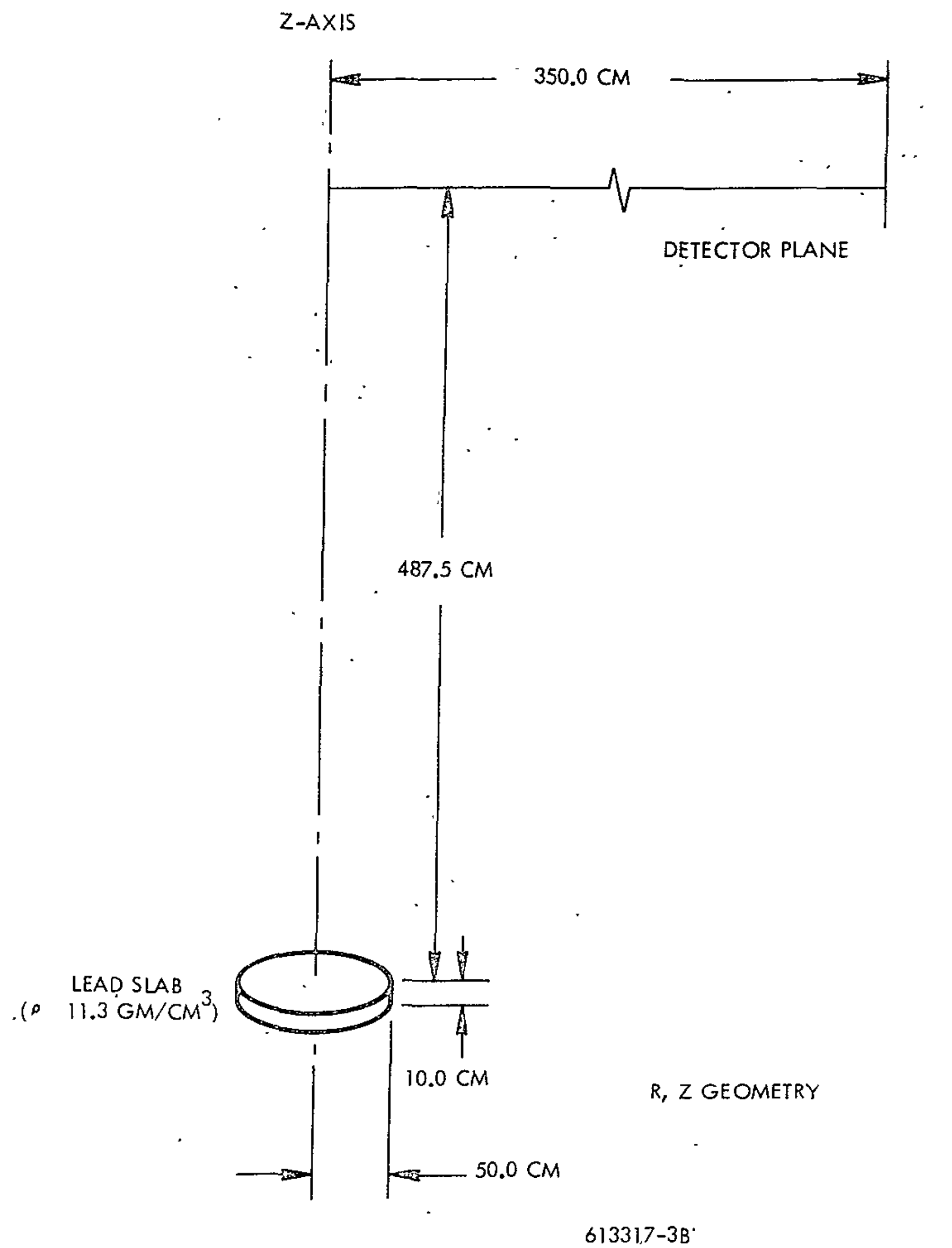

Figure 5-1. Geometrical Model For Lead Slab Test Problem

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TABLE 5-1

DOT-IIW CARD INPUT FOR DOT-IIW MAP SAMPLE PROBLEM

```
    30000    5    6    1    2    8    3    4    0    0    0    0    0    0    0        DATA  10
  SAMPLE DOT-IIW PROBLEM FOR THE MAP CODE,S6,P1,P8 SLAB                                DATA  20
           1           0           1          30           1           1DATA  30
          25           5           0         0.0         0.0      0.0001DATA  40
           1           0           0           0           0           1DATA  50
          18          12          12           0           0           0DATA  60
           0         0.0           2           3           5           6DATA  70
         1.0           0           3          10           1          10DATA  80
         0.0      0.0001         0.0         0.0         0.0         0.0DATA  90
           0          15          15           3           3           0DATA 100
           1           0           0           0         0.0           0DATA 110
14U                                                                     DATA 120
1.395272E&01      0.0   1.561528E&01      0.0   1.107841E-01      0.0   DATA 130
1.050735E&01      0.0   1.744405E&01      0.0   1.453281E&007.259415E-02DATA 140
    0.0           0.0       0.0           0.0   3.315655E-01      0.0   DATA 150
    0.0           0.0       0.0           0.0   4.240495E&001.609000E-01DATA 160
    0.0           0.0       0.0           0.0   5.499944E-01      0.0   DATA 170
    0.0           0.0       0.0           0.0   6.682676E&001.161059E-01DATA 180
    0.0           0.0       0.0           0.0   7.645300E-01      0.0   DATA 190
    0.0           0.0       0.0           0.0   8.591543E&00-4.87446E-02DATA 200
    0.0           0.0       0.0           0.0   9.736724E-01      0.0   DATA 210
    0.0           0.0       0.0           0.0   9.835920E&00-2.35591E-01DATA 220
    0.0           0.0       0.0           0.0   1.175978E&00      0.0   DATA 230
    0.0           0.0       0.0           0.0   1.035434E&01-3.20071E-01DATA 240
    0.0           0.0       0.0           0.0         0.0         0.0   DATA 250
    0.0           0.0       0.0           0.0         0.0         0.0   DATA 260
    0.0           0.0       0.0           0.0         0.0         0.0   DATA 270
    0.0           0.0       0.0           0.0         0.0         0.0   DATA 280
    0.0           0.0       0.0           0.0         0.0         0.0   DATA 290
    0.0           0.0       0.0           0.0         0.0         0.0   DATA 300
    0.0           0.0       0.0           0.0         0.0         0.0   DATA 310
    0.0           0.0       0.0           0.0         0.0         0.0   DATA 320
    0.0           0.0       0.0           0.0         0.0         0.0   DATA 330
    0.0           0.0       0.0           0.0         0.0         0.0   DATA 340
    0.0           0.0       0.0           0.0         0.0         0.0   DATA 350
    0.0           0.0       0.0           0.0         0.0         0.0   DATA 360
  T                                                                     DATA 370
 3*                                                                     DATA 380
  F     0.0                                                             DATA 390
  T                                                                     DATA 400
17*                                                                     DATA 410
         1.0         1.0                                                DATA 420
  T                                                                     DATA 430
17*                                                                     DATA 440
25R      1.0                                                            DATA 450
  T                                                                     DATA 460
17*                                                                     DATA 470
 4R      0.0         1.0                                                DATA 480
  T                                                                     DATA 490
 7U                                                                     DATA 500
-0.361248675-0.238619186 0.238619186-0.750201405-0.661209386-0.238619186DATA 510
 0.238619186 0.661209386-0.971113219-0.932469514-0.661209386-0.238619186DATA 520
 0.238619186 0.661209386 0.932469514-0.361248675-0.238619186 0.238619186DATA 530
-0.750201405-0.661209386-0.238619186 0.238619186 0.661209386-0.971113219DATA 540
-0.932469514-0.661209386-0.238619186 0.238619186 0.661209386 0.932469514DATA 550
-0.932469514-0.932469514-0.932469514-0.661209386-0.661209386-0.661209386DATA 560
-0.661209386-0.661209386-0.238619186-0.238619186-0.238619186-0.238619186DATA 570
-0.238619186-0.238619186-0.238619186 0.932469514 0.932469514 0.932469514DATA 580
```

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TABLE 5-1. (CONTINUED)

```
 0.661209386 0.661209386 0.661209386 0.661209386 0.661209386 0.238619186DATA 590
 0.238619186 0.238619186 0.238619186 0.238619186 0.238619186 0.238619186DATA 600
  T                                                                     DATA 610
 6U                                                                     DATA 620
 0.000000000 0.042831123 0.042831123 0.000000000 0.055238669 0.034951723DATA 630
 0.034951723 0.055238669 0.000000000 0.042831123 0.034951723 0.039195637DATA 640
 0.039195637 0.034951723 0.042831123 0.000000000 0.042831123 0.042831123DATA 650
 0.000000000 0.055238669 0.034951723 0.034951723 0.055238669 0.000000000DATA 660
 0.042831123 0.034951723 0.039195637 0.039195637 0.034951723 0.042831123DATA 670
  T                                                                     DATA 680
 4*                                                                     DATA 690
24I       0.0        50.0                                               DATA 700
 2*                                                                     DATA 710
 4I       0.0        10.0                                               DATA 720
 8$                                                                     DATA 730
25R         125R        125R        125R        125R        1           DATA 740
 9$                                                                     DATA 750
         -13                                                            DATA 760
 5*                                                                     DATA 770
  F  1.0                                                                DATA 780
10$                                                                     DATA 790
          13          13          14          14          15          15DATA 800
          16          16          17          17          18          18DATA 810
11$                                                                     DATA 820
           0           1           0           2           0           3DATA 830
           0           4           0           5           0           6DATA 840
12*                                                                     DATA 850
     0.0         0.03290     0.0         0.03290     0.0         0.03290DATA 860
     0.0         0.03290     0.0         0.03290     0.0         0.03290DATA 870
28$                                                                     DATA 880
           1                                                            DATA 890
  T                                                                     DATA 900
```

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TABLE 5-2

MAP CARD INPUT FOR DOT-IIW MAP SAMPLE PROBLEM

```
       9000                                                                DATA  10
 SAMPLE MAP  PROBLEM PB SLAB,COMMON PLANE,WITH INTERPOLATION               DATA  20
         25           0             5             0             6         3DATA  30
          2           1            30            15            30        15DATA  40
          0           0             1                                      DATA  50
          0           0             0.            0             0         0DATA  60
          1          37             1             1             1          DATA  70
  1.0        -487.5                                                        DATA  80
 1*                                                                        DATA  90
241       0.0        50.0                                                  DATA 100
 2*                                                                        DATA 110
 4I       0.0        10.0                                                  DATA 120
 3*                                                                        DATA 130
 5I0.0          180.0                                                      DATA 140
 4*                                                                        DATA 150
 2I 0.0         90.0                                                       DATA 160
 5$                                                                        DATA 170
          1          25                                                    DATA 180
 6$                                                                        DATA 190
          1           5                                                    DATA 200
 8U                                                                        DATA 210
-0.361248675-0.238619186 0.238619186-0.750201405-0.661209386-0.238619186DATA 220
 0.238619186 0.661209386-0.971113219-0.932469514-0.661209386-0.238619186DATA 230
 0.238619186 0.661209386 0.932469514-0.361248675-0.238619186 0.238619186DATA 240
-0.750201405-0.661209386-0.238619186 0.238619186 0.661209386-0.971113219DATA 250
-0.932469514-0.661209386-0.238619186 0.238619186 0.661209386 0.932469514DATA 260
-0.932469514-0.932469514-0.932469514-0.661209386-0.661209386-0.661209386DATA 270
-0.661209386-0.661209386-0.238619186-0.238619186-0.238619186-0.238619186DATA 280
-0.238619186-0.238619186-0.238619186 0.932469514 0.932469514 0.932469514DATA 290
 0.661209386 0.661209386 0.661209386 0.661209386 0.661209386 0.238619186DATA 300
 0.238619186 0.238619186 0.238619186 0.238619186 0.238619186 0.238619186DATA 310
 0.000000000 0.042831123 0.042831123 0.000000000 0.055238669 0.034951723DATA 320
 0.034951723 0.055238669 0.000000000 0.042831123 0.034951723 0.039195637DATA 330
 0.039195637 0.034951723 0.042831123 0.000000000 0.042831123 0.042831123DATA 340
 0.000000000 0.055238669 0.034951723 0.034951723 0.055238669 0.000000000DATA 350
 0.042831123 0.034951723 0.039195637 0.039195637 0.034951723 0.042831123DATA 360
10U                                                                        DATA 370
-0.361248675-0.238619186 0.238619186-0.750201405-0.661209386-0.238619186DATA 380
 0.238619186 0.661209386-0.971113219-0.932469514-0.661209386-0.238619186DATA 390
 0.238619186 0.661209386 0.932469514-0.361248675-0.238619186 0.238619186DATA 400
-0.750201405-0.661209386-0.238619186 0.238619186 0.661209386-0.971113219DATA 410
-0.932469514-0.661209386-0.238619186 0.238619186 0.661209386 0.932469514DATA 420
-0.932469514-0.932469514-0.932469514-0.661209386-0.661209386-0.661209386DATA 430
-0.661209386-0.661209386-0.238619186-0.238619186-0.238619186-0.238619186DATA 440
-0.238619186-0.238619186-0.238619186 0.932469514 0.932469514 0.932469514DATA 450
 0.661209386 0.661209386 0.661209386 0.661209386 0.661209386 0.238619186DATA 460
 0.238619186 0.238619186 0.238619186 0.238619186 0.238619186 0.238619186DATA 470
 0.000000000 0.042831123 0.042831123 0.000000000 0.055238669 0.034951723DATA 480
 0.034951723 0.055238669 0.000000000 0.042831123 0.034951723 0.039195637DATA 490
 0.039195637 0.034951723 0.042831123 0.000000000 0.042831123 0.042831123DATA 500
 0.000000000 0.055238669 0.034951723 0.034951723 0.055238669 0.000000000DATA 510
 0.042831123 0.034951723 0.039195637 0.039195637 0.034951723 0.042831123DATA 520
11H                                                                        DATA 530
  RESPONSE DATA                                                            DATA 540
12*                                                                        DATA 550
  F 1.0                                                                    DATA 560
15*                                                                        DATA 570
241 0.0      111 50.0        350.0                                         DATA 580
```

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TABLE 5-2 (CONTINUED)

DATA 590

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6.0 OUTPUT DATA DESCRIPTION

Output data from the MAP code consist of the printed output of the input data and calculated data, the optional magnetic tape output for use as input to DOT-IIW and the optional punched output of detector scalar flux. The following sections describe in detail each form of the output from the MAP code.

6.1 PRINTED OUTPUT

The user of MAP has the ability to chose the detail of printed output from a problem. The input word NPRT controls the detail of output.

The first part of the printed output is the input data and the results of an edit of this input data. The following quanities are presented:

1) The core memory allocated by the user, ISIZE.
2) The amount of core memory required for the problem, LAST.
3) The FIDO subroutine edit of the input data arrays on cards including the number of entries read. The FIDO subroutine returns an error message on input data read errors (See Section 5.3).
4) The title card and all input data to the code.
5) The DOT-IIW problem geometry data.
6) The detector surface (or coupling plane) geometry data including the type of surface, the input data for the surface and the actual calculated detector point coordinates.
7) The DOT surface angular quadrature data by discrete direction m where the columns are defined as:

μ_m	(Input direction cosines)
ξ_m	$(=\sqrt{1.0-\mu_m^2-\eta_m^2})$
η_m	(Input direction cosines)
ω_m	(Input quadrature weights)

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$\left.\begin{array}{l}\mu'_m \\ \mu''_m \\ \eta'_m \\ \eta''_m\end{array}\right\}$ (Calculated lower and upper direction cosines which define the fractional solid angle represented by each direction cosine)

8) The input response functions by group and type.
9) /Optional/ The ray trace geometry input data read edit from subroutine FIDO (If NZ is greater than 0).
10) /Optional/ The ray trace geometry input data.
11) /Optional/ The calculated detailed geometry data consisting of data calculated at the source surface, the discrete direction chosen for the source direction, the inverse square factor for each source point to detector point, etc. These data are for code checkout purposes only.
12) /Optional/ The r, z source surface leakage angular fluxes for the top and bottom surfaces (top surface data are associated with positive η direction cosines, bottom are associated with negative η direction cosines).
13) /Optional/ The r, z source surface leakage angular fluxes for the side surface (side surface data are associated with the positive μ direction cosines)
14) /Optional/ The angular flux data at the detector surface in discrete ordinate form.
15) The scalar flux at the detector surface for the top (or bottom), side and total visible surfaces. In addition, the particle current at the detector surface calculated from the calculated direction cosine normal to the surface (MAP) and the discrete ordinate direction cosine closest to this direction (DOT) are printed for the top and side surface data. The final calculated MAP data conserves particles by being multiplied by the ratio of direction cosines (MAP/DOT) to provide angular flux data for use in DOT-IIW as a boundary source.

NOTE: Items 12-15 are obtained for each group of the solution.

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16) The final response data for all detector points and source surface combinations for each response function.

The printed output from the DOT-IIW and MAP sample problems described in Section 5.0 are illustrated in Tables 6-1 and 6-2.

6.2 PUNCHED CARD OUTPUT

Punched card output from the MAP code is the scalar flux data at each detector point for each of the principal visible surfaces (total, top or bottom, side) for each energy group. These data are obtained on punched cards in a FORTRAN (6E12.5) format with each source surface data and each energy group data starting a new set of cards. The punched data for each energy group are in the order total source surface data, top or bottom source surface data and side source surface data.

6.3 TAPE OUTPUT

The output tape prepared by the MAP code is in the angular flux output tape format of the DOT-IIW (or DOT-II) code. This tape contains the angular flux at the detector surface in a discrete ordinate format which is directly useable in the DOT-IIW code as a top boundary source input tape. The tape format is as follows:

1) The first (NGN* 2) + 6 records are one word long (a single 0.0 word)
2) The next 6* NGN records contain the angular flux at the detector surface for the top or bottom, side, and total visible source surfaces. The six records of each energy group are the top or bottom source surface angular flux data as record 1, a single 0.0 word as records 2, 3, and 4, the side source surface angular flux data as record 5, and the total visible source surface data as record 6. These six records are repeated for each energy group.

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TABLE 6-1

DOT-IIW SAMPLE PROBLEM PRINTOUT FOR MAP SAMPLE PROBLEM

SAMPLE DOT-IIW PROBLEM FOR THE MAP CODE,S6,P1,P8 SLAB

A01	PROBLEM ID NO.	1	A02	0/1 = REG./ADJ.	0
A03	ORDER OF SCATTERING	1	A04	NUMBER OF ANGLES	30
IGE	0/1/2 = X-Y/R-Z/R-T	1	IZM	NO. OF MATERIAL ZONES	1
IM	NO. OF RADIAL INT.	25	JM	NO. OF AXIAL INT.	5
I04	0/1/2/3/4/5=Q/K/ALPHA/C/Z/BQ	0	EV	EIGENVALUE GUESS	0.
EVM	EIGENVALUE MODIFIER	0.	EPS	PRECISION DESIRED	1.00000E-04
B01	LEFT BOUNDARY CONDITION	1	B02	RIGHT BOUNDARY CONDITION	0
B03	TOP BOUNDARY CONDITION	0	B04	BOTTOM BOUNDARY CONDITION	0
M07	FLUX INPUT TRIGGER	0	MODE	FLUX CALCULATION MODE	1
MT	NO. OF MATERIALS	18	M01	MIXING TABLE LENGTH	12
MCR	NO. MATLS. FROM CARDS	12	MTP	NO. MATLS. FROM LIB TAPE	0
IZ	NO. RADIAL SEARCH ZONES	0	JZ	NO. AXIAL SEARCH ZONES	0
S02	0/1/2=NONE/K/ALPHA	0	S03	PARAM. EIGEN.-SEARCH	0.
IGM	NO. OF ENERGY GROUPS	2	IHT	POSITION OF SIGMA T	3
IHS	POSITION OF SIGMA GG	5	ITL	TABLE LENGTH	6
S01	NORMALIZATION FACTOR	1.00000E+00	M05	0/N=NO/N ACT. BY ZONE	0
M06	DISTR. SOURCE INPUT TRIGGER	3	S04	INITIAL INNER ITER. MAX.	10
D05	OUTER ITER. MAX.	1	G07	INNER ITER. MAX.	10
G05	NEUTRON BALANCE EPS.	0.	G06	POINTWISE FLUX EPS.	1.00000E-04
LAL	SEARCH EPSILON	0.	LAH	1-LAMBDA MAX.-SEARCH	0.
POD	PAR. OSC. DAMP-SEARCH	0.	EPSA	NEW PAR. EPS.-SEARCH	0.
IAFT	ANG. FLUX OUTPUT TRIGGER	0	A05	NO. OF +ETA ANGLES	15
A06	NO. OF -ETA ANGLES	15	A07	NO. OF +ETA INIT. DIRECTIONS	3
A08	NO. OF -ETA INIT. DIRECTIONS	3	A09	0/1/2/3=NORMAL/SOR/SPS/CA	0
A10	0/N=ALL/N ZONES OF CONVERGENCE	1	A11	0/N=ALL/NTH INTERVAL ANG FLUXES	0
A12	NO. OF NEUTRON GROUPS	0	A13	0/1=PRINT X-SEC/DO NOT	0
A14	UPSCATTER EPSILON	1.00000E-04	A15	ENTER ZERO	0
IXBS	0/1/2/3=NO/TOP/RIGHT/BOTH-TAPE	0	IMOLD	NO. OLD RADIAL INT.	0
JMOLD	NO. OLD AXIAL INT.	0	JMLEV	AXIAL ROW FOR BNDRY SOURCE	0
IDIR	0/1=UP/DOWN DIRECTION	0	NA	STARTING INTVL.BNDRY SOURCE	0
NC	FINAL INTVL.BNDRY SOURCE	0	ISIZE	AVAILABLE CORE DATA STORAGE	30000

5036 LOCATIONS WILL BE USED FOR THIS PROBLEM

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TABLE 6-1 (CONTINUED)

```
NON-STANDARD INPUT FORMAT USED
  14U ARRAY  144 ENTRIES READ
    T
   3* ARRAY    2 ENTRIES READ
    T
  17* ARRAY    2 ENTRIES READ
    T
  17* ARRAY   25 ENTRIES READ
    T
  17* ARRAY    5 ENTRIES READ
    T
NON-STANDARD INPUT FORMAT USED
   7U ARRAY   60 ENTRIES READ
    T
NON-STANDARD INPUT FORMAT USED
   6U ARRAY   30 ENTRIES READ
    T
   4* ARRAY   26 ENTRIES READ
   2* ARRAY    6 ENTRIES READ
   8$ ARRAY  125 ENTRIES READ
   9$ ARRAY    1 ENTRIES READ
   5* ARRAY    2 ENTRIES READ
  10$ ARRAY   12 ENTRIES READ
```

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TABLE 6-1 (CONTINUED)

```
11$ ARRAY   12 ENTRIES READ
12* ARRAY   12 ENTRIES READ
28$ ARRAY    1 ENTRIES READ
 T
```

TABLE 6-1 (CONTINUED)

REGION DESCRIPTION BY INTERVAL

XRR
Y
Z
T

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

TABLE 6-1 (CONTINUED)

MATERIAL DESCRIPTION BY INTERVAL

XRR
Y
Z
T

13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13

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NOT REPRODUCIBLE

TABLE 6-1 (CONTINUED)

I	WEIGHT	ETA	MU	MU * WT	ETA * WT	M3	M4
1	0.	-0.93246951E+00	-0.36124868E+00	0.	0.	0.	1
2	0.42831123E-01	-0.93246951E+00	-0.23861919E+00	-0.10220328E-01	-0.39938716E-01	0.23861919E+00	1
3	0.42831123E-01	-0.93246951E+00	0.23861919E+00	0.10220328E-01	-0.39938716E-01	0.23861919E+00	1
4	0.	-0.66120939E+00	-0.75020140E+00	0.	0.	0.	1
5	0.55238669E-01	-0.66120939E+00	-0.66120939E+00	-0.36524326E-01	-0.36524326E-01	0.66120939E+00	2
6	0.34951723E-01	-0.66120939E+00	-0.23861919E+00	-0.83401517E-02	-0.23110407E-01	0.23296064E+01	2
7	0.34951723E-01	-0.66120939E+00	0.23861919E+00	0.83401517E-02	-0.23110407E-01	0.23296064E+01	2
8	0.55238669E-01	-0.66120939E+00	0.66120939E+00	0.36524326E-01	-0.36524326E-01	0.66120939E+00	2
9	0.	-0.23861919E+00	-0.97111322E+00	0.	0.	0.	2
10	0.42831123E-01	-0.23861919E+00	-0.93246951E+00	-0.39938716E-01	-0.10220328E-01	0.93246951E+00	2
11	0.34951723E-01	-0.23861919E+00	-0.66120939E+00	-0.23110407E-01	-0.83401517E-02	0.29465741E+01	2
12	0.39195637E-01	-0.23861919E+00	-0.23861919E+00	-0.93528310E-02	-0.93528310E-02	0.34557693E+01	2
13	0.39195637E-01	-0.23861919E+00	0.23861919E+00	0.93528310E-02	-0.93528310E-02	0.34557693E+01	2
14	0.34951723E-01	-0.23861919E+00	0.66120939E+00	0.23110407E-01	-0.83401517E-02	0.29465741E+01	2
15	0.42831123E-01	-0.23861919E+00	0.93246951E+00	0.39938716E-01	-0.10220328E-01	0.93246951E+00	3
16	0.	0.93246951E+00	-0.36124868E+00	0.	0.	0.	[illegible]
17	0.42831123E-01	0.93246951E+00	-0.23861919E+00	-0.10220328E-01	0.39938716E-01	0.23861919E+00	[illegible]
18	0.42831123E-01	0.93246951E+00	0.23861919E+00	0.10220328E-01	0.39938716E-01	0.23861919E+00	[illegible]
19	0.	0.66120939E+00	-0.75020140E+00	0.	0.	0.	[illegible]
20	0.55238669E-01	0.66120939E+00	-0.66120939E+00	-0.36524326E-01	0.36524326E-01	0.66120939E+00	[illegible]
21	0.34951723E-01	0.66120939E+00	-0.23861919E+00	-0.83401517E-02	0.23110407E-01	0.23296064E+01	[illegible]
22	0.34951723E-01	0.66120939E+00	0.23861919E+00	0.83401517E-02	0.23110407E-01	0.23296064E+01	[illegible]
23	0.55238669E-01	0.66120939E+00	0.66120939E+00	0.36524326E-01	0.36524326E-01	0.66120939E+00	[illegible]
24	0.	0.23861919E+00	-0.97111322E+00	0.	0.	0.	[illegible]
25	0.42831123E-01	0.23861919E+00	-0.93246951E+00	-0.39938716E-01	0.10220328E-01	0.93246951E+00	1
26	0.34951723E-01	0.23861919E+00	-0.66120939E+00	-0.23110407E-01	0.83401517E-02	0.29465741E+01	1
27	0.39195637E-01	0.23861919E+00	-0.23861919E+00	-0.93528310E-02	0.93528310E-02	0.34557693E+01	1
28	0.39195637E-01	0.23861919E+00	0.23861919E+00	0.93528310E-02	0.93528310E-02	0.34557693E+01	1
29	0.34951723E-01	0.23861919E+00	0.66120939E+00	0.23110407E-01	0.83401517E-02	0.29465741E+01	1
30	0.42831123E-01	0.23861919E+00	0.93246951E+00	0.39938716E-01	0.10220328E-01	0.93246951E+00	1

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TABLE 6-1 (CONTINUED)

DISCRETE VALUES OF PLM(THETA)*COS(M*PSI)

ANGL	PLMC 1	PLMC 2
1	-3.61249E-01	-9.32470E-01
2	-2.38619E-01	-9.32470E-01
3	2.38619E-01	-9.32470E-01
4	-7.50201E-01	-6.61209E-01
5	-6.61209E-01	-6.61209E-01
6	-2.38619E-01	-6.61209E-01
7	2.38619E-01	-6.61209E-01
8	6.61209E-01	-6.61209E-01
9	-9.71113E-01	-2.38619E-01
10	-9.32470E-01	-2.38619E-01
11	-6.61209E-01	-2.38619E-01
12	-2.38619E-01	-2.38619E-01
13	2.38619E-01	-2.38619E-01
14	6.61209E-01	-2.38619E-01
15	9.32470E-01	-2.38619E-01
16	-3.61249E-01	9.32470E-01
17	-2.38619E-01	9.32470E-01
18	2.38619E-01	9.32470E-01
19	-7.50201E-01	6.61209E-01
20	-6.61209E-01	6.61209E-01
21	-2.38619E-01	6.61209E-01
22	2.38619E-01	6.61209E-01
23	6.61209E-01	6.61209E-01
24	-9.71113E-01	2.38619E-01
25	-9.32470E-01	2.38619E-01
26	-6.61209E-01	2.38619E-01
27	-2.38619E-01	2.38619E-01
28	2.38619E-01	2.38619E-01
29	6.61209E-01	2.38619E-01
30	9.32470E-01	2.38619E-01

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TABLE 6-1 (CONTINUED)

CROSS-SECTION EDIT

GROUP 1 CROSS-SECTIONS

POS.	MAT. 1	MAT. 2	MAT. 3	MAT. 4	MAT. 5	MAT. 6	MAT. 7	MAT. 8
1	1.39527E+01	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	1.56153E+01	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.
6	1.10784E-01	3.31565E-01	5.49994E-01	7.64530E-01	9.73672E-01	1.17598E+00	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.

POS.	MAT. 9	MAT. 10	MAT. 11	MAT. 12	MAT. 13	MAT. 14	MAT. 15	MAT. 16
1	0.	0.	0.	0.	4.59044E-01	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	5.13743E-01	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	3.64480E-03	1.09085E-02	1.80948E-02	2.51530E-02
7	0.	0.	0.	0.	0.	0.	0.	0.

POS.	MAT. 17	MAT. 18
1	0.	0.
	POS. 2 THRU POS. 5 SAME AS ABOVE	
6	3.20338E-02	3.86897E-02
7	0.	0.

GROUP 2 CROSS-SECTIONS

POS.	MAT. 1	MAT. 2	MAT. 3	MAT. 4	MAT. 5	MAT. 6	MAT. 7	MAT. 8
1	1.05073E+01	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	1.74440E+01	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.
6	1.45328E+00	4.24050E+00	6.68268E+00	8.59154E+00	9.83592E+00	1.03543E+01	0.	0.
7	7.25942E-02	1.60900E-01	1.16106E-01	-4.87446E-02	-2.35591E-01	-3.20071E-01	0.	0.

POS.	MAT. 9	MAT. 10	MAT. 11	MAT. 12	MAT. 13	MAT. 14	MAT. 15	MAT. 16
1	0.	0.	0.	0.	3.45692E-01	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	5.73909E-01	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.

TABLE 6-1 (CONTINUED)

```
    6  0.          0.          0.          0.          4.78129E-02  1.39512E-01  2.19960E-01  2.82662E-01
    7  0.          0.          0.          0.          2.38835E-03  5.29361E-03  3.81988E-03 -1.60370E-03
POS.   MAT.   17   MAT.   18
    1  0.          0.
       POS.     2 THRU POS.     5 SAME AS ABOVE
    6  3.23602E-01  3.40658E-01
    7 -7.75094E-03 -1.05303E-02
```


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TABLE 6-1 (CONTINUED)

```
DISTRIBUTED SOURCE FOR GROUP      1

XRR     YZT     1      YZT     2      YZT     3      YZT     4      YZT     5
   1  0.              0.             0.             0.             3.18310E-05
       XRR      2 THRU  XRR      25 SAME AS ABOVE

DISTRIBUTED SOURCE FOR GROUP      2

XRR     YZT     1      YZT     2      YZT     3      YZT     4      YZT     5
   1  0.              0.             0.             0.             3.18310E-05
       XRR      2 THRU  XRR      25 SAME AS ABOVE
```

TABLE 6-1 (CONTINUED)

	MIXTURE SUM	COMPONENT	DENSITY	RADIUS	R MIDPOINT	HEIGHT	H MIDPOINT	MAT. BY ZONE
1	13	0	0	0	1.00000E+00	0	1.00000E+00	-13
2	13	1	3.29000E-02	2.00000E+00	3.00000E+00	2.00000E+00	3.00000E+00	
3	14	0	0	4.00000E+00	5.00000E+00	4.00000E+00	5.00000E+00	
4	14	2	3.29000E-02	6.00000E+00	7.00000E+00	6.00000E+00	7.00000E+00	
5	15	0	0	8.00000E+00	9.00000E+00	8.00000E+00	9.00000E+00	
6	15	3	3.29000E-02	1.00000E+01	1.10000E+01	1.00000E+01		
7	16	0	0	1.20000E+01	1.30000E+01			
8	16	4	3.29000E-02	1.40000E+01	1.50000E+01			
9	17	0	0	1.60000E+01	1.70000E+01			
10	17	5	3.29000E-02	1.80000E+01	1.90000E+01			
11	18	0	0	2.00000E+01	2.10000E+01			
12	18	6	3.29000E-02	2.20000E+01	2.30000E+01			
13				2.40000E+01	2.50000E+01			
14				2.60000E+01	2.70000E+01			
15				2.80000E+01	2.90000E+01			
16				3.00000E+01	3.10000E+01			
17				3.20000E+01	3.30000E+01			
18				3.40000E+01	3.50000E+01			
19				3.60000E+01	3.70000E+01			
20				3.80000E+01	3.90000E+01			
21				4.00000E+01	4.10000E+01			
22				4.20000E+01	4.30000E+01			
23				4.40000E+01	4.50000E+01			
24				4.60000E+01	4.70000E+01			
25				4.80000E+01	4.90000E+01			
26				5.00000E+01				

	FIS. SPECTRUM	VELOCITY
1	0	1.00000E+00
2	0	1.00000E+00

ZONES OF CONVERGENCE

1

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TABLE 6-1 (CONTINUED)

```
FLUX  2 LC  0 II    0 NB  0.          USF  .          EQ  0.        EV  0.          LA  0.
  GROUP    1 INNER ITERATIONS =   5 FLUX ERROR MAX =  5.50426E-07   AT ( 19,  1)
  GROUP    2 INNER ITERATIONS =   6 FLUX ERROR MAX =  8.51931E-05   AT ( 12,  1)
FLUX  1 LC  1 II   11 NB  1.000000E+00 USF 0.         EQ  0.        EV  0.          LA  1.00000000E+00
```


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TABLE 6-1 (CONTINUED)

BALANCE TABLE SUMMARY

GROUP	FIXED SO	FISSION SO	IN-SCATTER	SELF-SCATTER	HZ-LEAKAGE	ABSORPTIONS	OUT-SCATTER	RT-LEAKAGE
1	5.00000E-01	0.	0.	2.69337E-03	7.82138E-03	3.39217E-01	3.77266E-02	7.82138E-03
2	5.00000E-01	0.	1.76490E-03	3.45114E-02	7.62901E-03	2.49521E-01	1.30216E-01	7.62901E-03
3	1.00000E+00	0.	1.76490E-03	3.72048E-02	1.54504E-02	5.88737E-01	1.67943E-01	1.54504E-02

GROUP	VT-LEAKAGE	TOP-LEAKAGE	NET-LEAKAGE	BALANCE
1	1.15236E-01	1.14759E-01	1.23057E-01	1.00000E+00
2	1.14399E-01	1.13518E-01	1.22028E-01	1.00000E+00
3	2.29635E-01	2.28277E-01	2.45085E-01	1.00000E+00

FLUX 1 LC 2 II 0 NB 1.000000E+00 USF 0. EQ 0. EV 0. LA 1.00000000E+00

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TABLE 6-1 (CONTINUED)

I	RADIUS	R MIDPOINT	HEIGHT	H MIDPOINT
1	0.	1.0000000E+00	0.	1.0000000E+00
2	2.0000000E+00	3.0000000E+00	2.0000000E+00	3.0000000E+00
3	4.0000000E+00	5.0000000E+00	4.0000000E+00	5.0000000E+00
4	6.0000000E+00	7.0000000E+00	6.0000000E+00	7.0000000E+00
5	8.0000000E+00	9.0000000E+00	8.0000000E+00	9.0000000E+00
6	1.0000000E+01		1.0000000E+01	
		1.1000000E+01		
7	1.2000000E+01	1.3000000E+01		
8	1.4000000E+01	1.5000000E+01		
9	1.6000000E+01	1.7000000E+01		
10	1.8000000E+01	1.9000000E+01		
11	2.0000000E+01	2.1000000E+01		
12	2.2000000E+01	2.3000000E+01		
13	2.4000000E+01	2.5000000E+01		
14	2.6000000E+01	2.7000000E+01		
15	2.8000000E+01	2.9000000E+01		
16	3.0000000E+01	3.1000000E+01		
17	3.2000000E+01	3.3000000E+01		
18	3.4000000E+01	3.5000000E+01		
19	3.6000000E+01	3.7000000E+01		
20	3.8000000E+01	3.9000000E+01		
21	4.0000000E+01	4.1000000E+01		
22	4.2000000E+01	4.3000000E+01		
23	4.4000000E+01	4.5000000E+01		
24	4.6000000E+01	4.7000000E+01		
25	4.8000000E+01	4.9000000E+01		
26	5.0000000E+01			

TABLE 6-1 (CONTINUED)

FLUX FOR GROUP 1

XRR	YZT= 1	YZT= 2	YZT= 3	YZT= 4	YZT= 5
1	1.4714E-07	4.9732E-07	1.8313E-06	1.1655E-05	3.3471E-05
2	1.5510E-07	5.2470E-07	1.9704E-06	1.1797E-05	3.3471E-05
3	1.5675E-07	4.9774E-07	1.9947E-06	1.174[illegible]E-05	3.3471E-05
4	1.2924E-07	4.8352E-07	2.0252E-06	1.1759E-05	3.3471E-05
5	1.3768E-07	4.5583E-07	2.0605E-06	1.1754E-05	3.3470E-05
6	1.2251E-07	4.5687E-07	2.0618E-06	1.1753E-05	3.3471E-05
7	1.4565E-07	4.6210E-07	2.0513E-06	1.1757E-05	3.3470E-05
8	1.2478E-07	4.6200E-07	2.0583E-06	1.1751E-05	3.3472E-05
9	1.4764E-07	4.6308E-07	2.0462E-06	1.1759E-05	3.3469E-05
10	1.1654E-07	4.7983E-07	2.0549E-06	1.1748E-05	3.3474E-05
11	1.3438E-07	4.5085E-07	2.0719E-06	1.1763E-05	3.3467E-05
12	1.1197E-07	4.6382E-07	2.0828E-06	1.1744E-05	3.3477E-05
13	1.3335E-07	4.4876E-07	2.0825E-06	1.1768E-05	3.3463E-05
14	1.1933E-07	4.6289E-07	2.0648E-06	1.1738E-05	3.3483E-05
15	1.4763E-07	4.6466E-07	2.0349E-06	1.1775E-05	3.3453E-05
16	1.2524E-07	4.7968E-07	2.0668E-06	1.1730E-05	3.3496E-05
17	1.1451E-07	4.4692E-07	2.1080E-06	1.1782E-05	3.3433E-05
18	1.2864E-07	4.6757E-07	2.0203E-06	1.1724E-05	3.3527E-05
19	1.3642E-07	4.9443E-07	2.0828E-06	1.1768E-05	3.3387E-05
20	1.5380E-07	4.4302E-07	1.9988E-06	1.1770E-05	3.3599E-05
21	1.6385E-07	5.6581E-07	2.0770E-06	1.1541E-05	3.3268E-05
22	1.6727E-07	5.1675E-07	2.2117E-06	1.1189E-05	3.3796E-05
23	1.6355E-07	6.1954E-07	2.2900E-06	1.0915E-05	3.2865E-05
24	1.2601E-07	4.8678E-07	2.0836E-06	1.0982E-05	3.4427E-05
25	9.8535E-08	3.3451E-07	1.5707E-06	8.5834E-06	2.7527E-05

TABLE 6-1 (CONTINUED)

FLUX FOR GROUP 2

XRR	YZT= 1	YZT= 2	YZT= 3	YZT= 4	YZT= 5
1	2.9062E-07	8.7[illegible]32E-07	2.7994E-06	9.8344E-06	3.[illegible]895E-05
2	2.8057E-07	8.5886E-07	2.7803E-06	9.8655E-06	3.2896E-05
3	2.5320E-07	7.2689E-07	2.3739E-06	1.0416E-05	3.2895E-05
4	2.2844E- 7	7.1984E-07	2.4172E-06	1.0527E-05	3.2897E-05
5	2.3739E- 7	6.9133E-07	2.4124E-06	1.0459E-05	3.2896E-05
6	2.2452E-07	7.1574E-07	2.4167E-06	1.0507E-05	3.2898E-05
7	2.3791E-07	6.921[illegible]E-07	2.4229E-06	1.0473E-05	3.2896E-05
8	2.1481E-07	6.8595E-07	2.4553E-06	1.0493E-05	3.2899E-05
9	2.3464E-07	6.9625E-07	2.4373E-06	1.0481E-05	3.2394E-05
10	2.1628E-07	6.8941E-07	2.4406E-06	1.0484E-05	3.2900E-05
11	2.3154E-07	6.9569E-07	2.4412E-06	1.0487E-05	3.2892E-05
12	2.1658E-07	6.9459E-07	2.4418E-06	1.0478E-05	3.2903E-05
13	2.3112E-07	6.9186E-07	2.4440E-06	1.0492E-05	3.2888E-05
14	2.1576E-07	7.0014E-07	2.4358E-06	1.0472E-05	3.2910E-05
15	2.2369E-07	6.8802E-07	2.4500E-06	1.0496E-05	3.2878E-05
16	2.19[illegible]8E-07	7.0563E-07	2.4251E-06	1.0469E-05	3.2924E-05
17	2.2067E-07	6.8568E-07	2.4618E-06	1.0496E-05	3.2857E-05
18	2.3369E-07	6.9380E-07	2.4072E-06	1.0471E-05	3.2956E-05
19	2.2345E-07	7.0175E-07	2.4758E-06	1.0479E-05	3.2809E-05
20	2.3686E-07	6.6143E-07	2.3842E-06	1.0492E-05	3.3028E-05
21	2.1519E-07	7.1727E-07	2.4663E-06	1.0400E-05	3.2691E-05
22	2.1297E-07	6.2658E-07	2.3665E-06	1.0537E-05	3.3221E-05
23	2.0821E-07	7.1491E-07	2.3309E-06	1.0051E-05	3.2299E-05
24	1.9707E-07	6.6234E-07	2.4468E-06	9.9630E-06	3.3876E-05
25	1.4316E-07	4.5869E-07	1.7094E-06	7.9065E-06	2.7127E-05

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TABLE 6-1 (CONTINUED)

FISSION EDIT

XRR	YZT= 1	YZT= 2	YZT= 3	YZT= 4	YZT= 5
1	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.

TABLE 6-1 (CONTINUED)

END OF PROBLEM - TAPE DESIGNATION

FORTRAN NAME	LOGICAL NO.
NCR1	3
NSCRAT	2
NBSO	8
NFLUX1	1
NAFT	4

TABLE 6-2

MAP SAMPLE PROBLEM PRINTOUT

```
THIS PROBLEM HAS AN ASSIGNED DATA ARRAY OF    9000 LOCATIONS(ISIZE)

THIS PROBLEM REQUIRES A DATA ARRAY OF    5207 LOCATIONS(LAST)

    1* ARRAY      26 ENTRIES READ
    2* ARRAY       6 ENTRIES READ
    3* ARRAY       7 ENTRIES READ
    4* ARRAY       4 ENTRIES READ
    5$ ARRAY       2 ENTRIES READ
NON-STANDARD INPUT FORMAT USED
    6$ ARRAY       2 ENTRIES READ
NON-STANDARD INPUT FORMAT USED
    8U ARRAY      90 ENTRIES READ
NON-STANDARD INPUT FORMAT USED
   10U ARRAY      90 ENTRIES READ
   11H ARRAY      18 ENTRIES READ
   12* ARRAY       2 ENTRIES READ
   15* ARRAY      38 ENTRIES READ
     T
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TABLE 6-2 (CONTINUED)

SAMPLE MAP PROBLEM PB SLAB.COMMON PLANE.WITH INTERPOLATION

INPUT DATA

```
NO. OF RADIAL MESH IN DOT PROBLEM..........NRI=   25
NO. OF RADIAL MESH IN MAP PROBLEM..........NRK=    0
NO. OF AXIAL MESH IN DOT PROBLEM...........NZI=    5
NO. OF AXIAL MESH IN MAP PROBLEM...........NZK=    0
NO. OF AZIMUTHIAL MESH INTERVALS-END.......NMU=    6
NO. OF AZIMUTHIAL MESH INTERVALS-SIDE.....NMUS=    3
NO. OF GROUPS..............................NGN=    2
ORDER OF P(L) SCATTERING IN DOT PROBLEM....NPL=    1
NO. OF DISCRETE DIRECTIONS IN DOT..........NQI=   30
NO. OF UP DISCRETE DIRECTIONS IN DOT......NQIU=   15
NO. OF DISCRETE DIRECTIONS IN MAP..........NQJ=   30
NO. OF UP DISCRETE DIRECTIONS IN MAP......NQJU=   15
INTERPLATION TECHNIQUE.....................NIT=    0
CARD OR TAPE OUTPUT OPTION................NPNH=    0
PRINT OUTPUT OPTION.......................NPRT=    1
NO. OF ZONES IN GEOMETRY....................NZ=    0
NO. OF ELEMENTS IN COMPONENT-MIXTURE TABLE..NE=    0
NO. OF MIXTURES IN COMPONENT-MIXTURE TABLE..NM=    0
NO. OF BOUNDARIES IN GEOMETRY...............NB=    0
XS OPTION 0/1. CARDS/CALCULATE.............NBA=    0
MATERIAL BUILDUP TYPE......................NBT=    0
TYPE OF SURFACE DETECTOR.................NTSUR=    1
NO. OF MESH IN MAP PROBLEM.................NRJ=   37
NO. OF TAGGED SURFACES ON END SURFACE......NAT=    1
NO. OF TAGGED SURFACES ON SIDE SURFACE.....NAS=    1
NO. OF RESPONSE FUNCTIONS..................NRP=    1
NORMALIZATION FACTOR.....................SCALE=  0.10000E+01
```

DOT PROBLEM GEOMETRY

RADIAL MESH NO	R(I)	MIDPOINT
1	0.	1.00000E+00
2	2.00000E+00	3.00000E+00
3	4.00000E+00	5.00000E+00
4	6.00000E+00	7.00000E+00
5	8.00000E+00	9.00000E+00
6	1.00000E+01	1.10000E+01
7	1.20000E+01	1.30000E+01
8	1.40000E+01	1.50000E+01
9	1.60000E+01	1.70000E+01
10	1.80000E+01	1.90000E+01
11	2.00000E+01	2.10000E+01

TABLE 6-2 (CONTINUED)

12	2.20000E+01	2.30000E+01
13	2.40000E+01	2.50000E+01
14	2.60000E+01	2.70000E+01
15	2.80000E+01	2.90000E+01
16	3.00000E+01	3.10000E+01
17	3.20000E+01	3.30000E+01
18	3.40000E+01	3.50000E+01
19	3.60000E+01	3.70000E+01
20	3.80000E+01	3.90000E+01
21	4.00000E+01	4.10000E+01
22	4.20000E+01	4.30000E+01
23	4.40000E+01	4.50000E+01
24	4.60000E+01	4.70000E+01
25	4.80000E+01	4.90000E+01
	5.00000E+01	

AXIAL MESH NO.	Z(J)	MIDPOINT
1	0.	1.00000E+00
2	2.00000E+00	3.00000E+00
3	4.00000E+00	5.00000E+00
4	6.00000E+00	7.00000E+00
5	8.00000E+00	9.00000E+00
	1.00000E+01	

COUPLING PLANE GEOMETRY DATA

AXIAL COORDINATE....(ZR)= -4.87500E+02

MESH LINE NO.	RADIAL COORDINATE
1	0.
2	2.00000E+00
3	4.00000E+00
4	6.00000E+00
5	8.00000E+00
6	1.00000E+01
7	1.20000E+01
8	1.40000E+01
9	1.60000E+01
10	1.80000E+01
11	2.00000E+01
12	2.20000E+01
13	2.40000E+01
14	2.60000E+01
15	2.80000E+01
16	3.00000E+01
17	3.20000E+01

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TABLE 6-2 (CONTINUED)

18	3.40000E+01
19	3.60000E+01
20	3.80000E+01
21	4.00000E+01
22	4.20000E+01
23	4.40000E+01
24	4.60000E+01
25	4.80000E+01
26	5.00000E+01
27	7.50000E+01
28	1.00000E+02
29	1.25000E+02
30	1.50000E+02
31	1.75000E+02
32	2.00000E+02
33	2.25000E+02
34	2.50000E+02
35	2.75000E+02
36	3.00000E+02
37	3.25000E+02

POINTWISE GEOMETRY DATA

DETECTOR POINT COORDINATES

MESH POINT NO.	RADIAL COORDINATE	AXIAL COORDINATE
1	1.00000E+00	-4.87500E+02
2	3.00000E+00	-4.87500E+02
3	5.00000E+00	-4.87500E+02
4	7.00000E+00	-4.87500E+02
5	9.00000E+00	-4.97500E+02
6	1.10000E+01	-4.87500E+02
7	1.30000E+01	-4.87500E+02
8	1.50000E+01	-4.87500E+02
9	1.70000E+01	-4.87500E+02
10	1.90000E+01	-4.87500E+02
11	2.10000E+01	-4.87500E+02
12	2.30000E+01	-4.87500E+02
13	2.50000E+01	-4.87500E+02
14	2.70000E+01	-4.87500E+02
15	2.90000E+01	-4.87500E+02
16	3.10000E+01	-4.87500E+02
17	3.30000E+01	-4.87500E+02
18	3.50000E+01	-4.87500E+02
19	3.70000E+01	-4.87500E+02

TABLE 6-2 (CONTINUED)

20	3.90000E+01	-4.87500E+02
21	4.10000E+01	-4.87500E+02
22	4.30000E+01	-4.87500E+02
23	4.50000E+01	-4.87500E+02
24	4.70000E+01	-4.87500E+02
25	4.90000E+01	-4.87500E+02
26	6.25000E+01	-4.87500E+02
27	8.75000E+01	-4.87500E+02
28	1.12500E+02	-4.87500E+02
29	1.37500E+02	-4.87500E+02
30	1.62500E+02	-4.87500E+02
31	1.87500E+02	-4.87500E+02
32	2.12500E+02	-4.87500E+02
33	2.37500E+02	-4.87500E+02
34	2.62500E+02	-4.87500E+02
35	2.87500E+02	-4.87500E+02
36	3.12500E+02	-4.87500E+02
37	3.37500E+02	-4.87500E+02

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TABLE 6-2 (CONTINUED)

DOT SURFACE QUADRATURE DATA(MU,PSI,EA,W,LIMITS)

1	-3.01249E-01	1.64725E-05	-9.32470E-01	0.	0.	0.	0.	0.
2	-2.38619E-01	2.71222E-01	-9.32470E-01	4.28311E-02	-1.00000E+00	-5.12473E-12	-8.28676E-01	-1.00000E+00
3	2.38619E-01	2.71222E-01	-9.32470E-01	4.28311E-02	-5.12473E-12	1.00000E+00	-8.28676E-01	-1.00000E+00
4	-7.50201E-01	0.	-6.61209E-01	0.	0.	0.	0.	0.
5	-6.61209E-01	3.54407E-01	-6.61209E-01	5.52387E-02	-1.00000E+00	-5.71830E-01	-4.67914E-01	-8.28676E-01
6	-2.38619E-01	7.11240E-01	-6.61209E-01	3.49517E-02	-5.71830E-01	-5.12473E-12	-4.67914E-01	-8.28676E-01
7	2.38619E-01	7.11240E-01	-6.61209E-01	3.49517E-02	-5.12473E-12	5.71830E-01	-4.67914E-01	-8.28676E-01
8	6.61209E-01	3.54407E-01	-6.61209E-01	5.52387E-02	5.71830E-01	1.00000E+00	-4.67914E-01	-8.28676E-01
9	-9.71113E-01	0.	-2.38619E-01	0.	0.	0.	0.	0.
10	-9.32470E-01	2.71222E-01	-2.38619E-01	4.28311E-02	-1.00000E+00	-8.39116E-01	-7.99998E-09	-4.67914E-01
11	-6.61209E-01	7.11240E-01	-2.38619E-01	3.49517E-02	-8.39116E-01	-5.02357E-01	-7.99998E-09	-4.67914E-01
12	-2.38619E-01	9.41340E-01	-2.38619E-01	3.91956E-02	-5.02357E-01	-5.12473E-12	-7.99998E-09	-4.67914E-01
13	2.38619E-01	9.41340E-01	-2.38619E-01	3.91956E-02	-5.12473E-12	5.02357E-01	-7.99998E-09	-4.67914E-01
14	6.61209E-01	7.11240E-01	-2.38619E-01	3.49517E-02	5.02357E-01	8.39116E-01	-7.99998E-09	-4.67914E-01
15	9.32470E-01	2.71222E-01	-2.38619E-01	4.28311E-02	8.39116E-01	1.00000E+00	-7.99998E-09	-4.67914E-01
16	-3.01249E-01	1.64725E-05	9.32470E-01	0.	0.	0.	0.	0.
17	-2.38619E-01	2.71222E-01	9.32470E-01	4.28311E-02	-1.00000E+00	-5.12473E-12	1.00000E+00	8.28676E-01
18	2.38619E-01	2.71222E-01	9.32470E-01	4.28311E-02	-5.12473E-12	1.00000E+00	1.00000E+00	8.28676E-01
19	-7.50201E-01	0.	6.61209E-01	0.	0.	0.	0.	0.
20	-6.61209E-01	3.54407E-01	6.61209E-01	5.52387E-02	-1.00000E+00	-5.71830E-01	8.28676E-01	4.67914E-01
21	-2.38619E-01	7.11240E-01	6.61209E-01	3.49517E-02	-5.71830E-01	-5.12473E-12	8.28676E-01	4.67914E-01
22	2.38619E-01	7.11240E-01	6.61209E-01	3.49517E-02	-5.12473E-12	5.71830E-01	8.28676E-01	4.67914E-01
23	6.61209E-01	3.54407E-01	6.61209E-01	5.52387E-02	5.71830E-01	1.00000E+00	8.28676E-01	4.67914E-01
24	-9.71113E-01	0.	2.38619E-01	0.	0.	0.	0.	0.
25	-9.32470E-01	2.71222E-01	2.38619E-01	4.28311E-02	-1.00000E+00	-8.39116E-01	4.67914E-01	7.99998E-09
26	-6.61209E-01	7.11240E-01	2.38619E-01	3.49517E-02	-8.39116E-01	-5.02357E-01	4.67914E-01	7.99998E-09
27	-2.38619E-01	9.41340E-01	2.38619E-01	3.91956E-02	-5.02357E-01	-5.12473E-12	4.67914E-01	7.99998E-09
28	2.38619E-01	9.41340E-01	2.38619E-01	3.91956E-02	-5.12473E-12	5.02357E-01	4.67914E-01	7.99998E-09
29	6.61209E-01	7.11240E-01	2.38619E-01	3.49517E-02	5.02357E-01	8.39116E-01	4.67914E-01	7.99998E-09
30	9.32470E-01	2.71222E-01	2.38619E-01	4.28311E-02	8.39116E-01	1.00000E+00	4.67914E-01	7.99998E-09

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TABLE 6-2 (CONTINUED)

DOT SURFACE QUADRATURE DATA(MU,PSI,EA,W,LIMITS)

1	-3.61249E-01	1.64725E-05	-9.32470E-01	0.	0.	0.	0.	0.
2	-2.38619E-01	2.71222E-01	-9.32470E-01	4.28311E-02	-1.00000E+00	-5.12473E-12	-8.28676E-01	-1.00000E+00
3	2.38619E-01	2.71222E-01	-9.32470E-01	4.28311E-02	-5.12473E-12	1.00000E+00	-8.28676E-01	-1.00000E+00
4	-7.50201E-01	0.	-6.61209E-01	0.	0.	0.	0.	0.
5	-6.61209E-01	3.54407E-01	-6.61209E-01	5.52387E-02	-1.00000E+00	-5.71830E-01	-4.67914E-01	-8.28676E-01
6	-2.38619E-01	7.11240E-01	-6.61209E-01	3.49517E-02	-5.71830E-01	-5.12473E-12	-4.67914E-01	-8.28676E-01
7	2.38619E-01	7.11240E-01	-6.61209E-01	3.49517E-02	-5.12473E-12	5.71830E-01	-4.67914E-01	-8.28676E-01
8	6.61209E-01	3.54407E-01	-6.61209E-01	5.52387E-02	5.71830E-01	1.00000E+00	-4.67914E-01	-8.28676E-01
9	-9.71113E-01	0.	-2.38619E-01	0.	0.	0.	0.	0.
10	-9.32470E-01	2.71222E-01	-2.38619E-01	4.28311E-02	-1.00000E+00	-8.39116E-01	-7.99998E-09	-4.67914E-01
11	-6.61209E-01	7.11240E-01	-2.38619E-01	3.49517E-02	-8.39116E-01	-5.02357E-01	-7.99998E-09	-4.67914E-01
12	-2.38619E-01	9.41340E-01	-2.38619E-01	3.91956E-02	-5.02357E-01	-5.12473E-12	-7.99998E-09	-4.67914E-01
13	2.38619E-01	9.41340E-01	-2.38619E-01	3.91956E-02	-5.12473E-12	5.02357E-01	-7.99998E-09	-4.67914E-01
14	6.61209E-01	7.11240E-01	-2.38619E-01	3.49517E-02	5.02357E-01	8.39116E-01	-7.99998E-09	-4.67914E-01
15	9.32470E-01	2.71222E-01	-2.38619E-01	4.28311E-02	8.39116E-01	1.00000E+00	-7.99998E-09	-4.67914E-01
16	-3.61249E-01	1.64725E-05	9.32470E-01	0.	0.	0.	0.	0.
17	-2.38619E-01	2.71222E-01	9.32470E-01	4.28311E-02	-1.00000E+00	-5.12473E-12	1.00000E+00	8.28676E-01
18	2.38619E-01	2.71222E-01	9.32470E-01	4.28311E-02	-5.12473E-12	1.00000E+00	1.00000E+00	8.28676E-01
19	-7.50201E-01	0.	6.61209E-01	0.	0.	0.	0.	0.
20	-6.61209E-01	3.54407E-01	6.61209E-01	5.52387E-02	-1.00000E+00	-5.71830E-01	8.28676E-01	4.67914E-01
21	-2.38619E-01	7.11240E-01	6.61209E-01	3.49517E-02	-5.71830E-01	-5.12473E-12	8.28676E-01	4.67914E-01
22	2.38619E-01	7.11240E-01	6.61209E-01	3.49517E-02	-5.12473E-12	5.71830E-01	8.28676E-01	4.67914E-01
23	6.61209E-01	3.54407E-01	6.61209E-01	5.52387E-02	5.71830E-01	1.00000E+00	8.28676E-01	4.67914E-01
24	-9.71113E-01	0.	2.38619E-01	0.	0.	0.	0.	0.
25	-9.32470E-01	2.71222E-01	2.38619E-01	4.28311E-02	-1.00000E+00	-8.39116E-01	4.67914E-01	7.99998E-09
26	-6.61209E-01	7.11240E-01	2.38619E-01	3.49517E-02	-8.39116E-01	-5.02357E-01	4.67914E-01	7.99998E-09
27	-2.38619E-01	9.41340E-01	2.38619E-01	3.91956E-02	-5.02357E-01	-5.12473E-12	4.67914E-01	7.99998E-09
28	2.38619E-01	9.41340E-01	2.38619E-01	3.91956E-02	-5.12473E-12	5.02357E-01	4.67914E-01	7.99998E-09
29	6.61209E-01	7.11240E-01	2.38619E-01	3.49517E-02	5.02357E-01	8.39116E-01	4.67914E-01	7.99998E-09
30	9.32470E-01	2.71222E-01	2.38619E-01	4.28311E-02	8.39116E-01	1.00000E+00	4.67914E-01	7.99998E-09

TABLE 6-2 (CONTINUED)

RESPONSE DATA GROUP NO.=

	1	2
1	1.00000E+00	1.00000E+00

TABLE 6-2 (CONTINUED)

SURFACE FLUX,TOP GROUP NO.= 1

	1	2	3	4	5	6	7	8
1	2.63558E-07	1.71895E-07	4.85099E-07	1.29126E-06	2.70283E-07	3.21931E-07	3.50822E-07	3.71336E-07
2	3.96543E-07	4.30340E-07	1.64814E-07	1.29139E-06	3.20965E-07	4.69157E-07	1.22457E-07	4.05879E-07
3	2.235[illegible]5E-07	2.79371E-07	4.72742E-07	1.29141E-06	3.47901E-07	5.04069E-07	2.37979E-07	1.80433E-07
4	4.42921E-07	4.38265E-07	1.82780E-07	1.29171E-06	3.63507E-07	4.44733E-07	9.20689E-08	7.73607E-08
5	1.72646E-07	2.81274E-07	4.49901E-07	1.29122E-06	3.73923E-07	9.75434E-08	3.39420E-07	1.35229E-07
6	4.89760E-07	4.61358E-07	2.07583E-07	1.29112E-06	3.81197E-07	1.24263E-07	3.47761E-07	1.19763E-08
7	1.43759E-07	2.64530E-07	4.24006E-07	1.29129E-06	3.86890E-07	1.17475E-07	3.47445E-07	6.82432E-08
8	4.74335E- 7	4.38271E-07	2.33141E-07	1.29115E-06	3.91021E-07	1.45864E-07	3.54202E-07	5.75703E-08
9	2.50242E-07	2.08798E-07	3.97574E-07	1.29131E-06	3.94615E-07	1.39908E-07	3.54290E-07	5.67339E-08
10	5.12178E-07	4.26756E-07	2.55225E-07	1.29111E-06	3.97212E-07	5.74285E-08	4.21585E-08	3.46077E-08
11	2.39316E-07	2.87752E-07	3.75551E-07	1.29124E-06	3.99682E-07	1.38461E-07	1.88039E-07	8.64922E-08
12	4.71566E-07	4.27149E-07	2.72552E-07	1.29107E-06	4.01535E-07	7.30482E-08	3.62765E-08	1.25894E-07
13	2.27491E-07	3.23607E-07	3.58141E-07	1.29117E-06	4.03450E-07	7.95615E-08	7.68139E-08	1.31465E-07
14	4.26577E-07	2.60329E-07	2.88654E-07	1.29095E-06	4.05063E-07	2.23187E-07	2.66805E-08	1.30852E-07
15	2.02634E-07	3.99265E-07	3.46484E-07	1.29073E-06	4.07072E-07	7.23680E-08	1.68577E-07	1.37864E-07
16	3.56021E-07	2.78357E-07	3.00191E-07	1.28954E-06	4.09635E-07	4.18917E-09	5.02747E-08	4.45244E-08
17	3.82132E-07	5.30440E-07	3.40123E-07	1.28694E-06	4.14753E-07	8.79010E-08	9.91892E-09	1.23610E-07
18	7.02024E-08	1.60913E-07	3.05470E-07	1.28134E-06	4.28922E-07	1.45035E-07	5.79874E-08	7.59533E-08
19	6.45280E-07	5.00205E-07	3.34809E-07	1.26913E-06	4.65401E-07	4.82073E-07	1.44482E-07	3.53674E-08
20	4.99381E-08	3.94948E-07	3.15536E-07	1.23890E-06	2.83394E-07	2.89811E-07	4.90385E-08	4.74564E-08
21	6.26241E-07	2.12306E-07	3.27825E-07	1.17783E-06	3.74695E-07	2.22160E-08	1.38733E-07	4.26813E-08
22	3.11679E-07	5.05591E-07	3.14125E-07	1.05844E-06	1.11518E-06	3.19096E-07	5.67695E-08	2.93572E-10
23	4.75934E-08	2.97946E-07	5.51249E-07	8.48579E-07	9.25943E-07	5.59463E-07	1.59703E-07	1.09627E-08
24	6.17974E-09	6.74177E-08	2.75391E-07	5.34939E-07	6.16168E-07	1.79077E-07	5.72918E-08	3.05486E-07
25	1.28238E-09	6.48879E-09	3.50244E-07	1.77271E-07	2.15833E-07	5.94289E-07	1.86508E-07	1.27593E-07

	9	10	11	12	13	14	15	16
1	1.10455E-07	1.10454E-07	1.10452E-07	1.10447E-07	1.10445E-07	1.10452E-07	1.10475E-07	4.41796E-05
2	1.10517E-07	1.10516E-07	1.10515E-07	1.10522E-07	1.10534E-07	1.10545E-07	1.10561E-07	4.41799E-05
3	1.10554E-07	1.10552E-07	1.10542E-07	1.10536E-07	1.10527E-07	1.10504E-07	1.10492E-07	4.41796E-05
4	1.10441E-07	1.10436E-07	1.10403E-07	1.10347E-07	1.10296E-07	1.10273E-07	1.10261E-07	4.41799E-05
5	1.10435E-07	1.10431E-07	1.10406E-07	1.10367E-07	1.10316E-07	1.10260E-07	1.10223E-07	4.41794E-05
6	1.10358E-07	1.10355E-07	1.10322E-07	1.10259E-07	1.10205E-07	1.10181E-07	1.10161E-07	4.41803E-05
7	1.10442E-07	1.10441E-07	1.10446E-07	1.10423E-07	1.10358E-07	1.10291E-07	1.10242E-07	4.41789E-05
8	1.10359E-07	1.10360E-07	1.10334E-07	1.10278E-07	1.10232E-07	1.10212E-07	1.10169E-07	4.41812E-05
9	1.10454E-07	1.10460E-07	1.10454E-07	1.10435E-07	1.10381E-07	1.10303E-07	1.10253E-07	4.41773E-05
10	1.10300E-07	1.10312E-07	1.10297E-07	1.10229E-07	1.10184E-07	1.10161E-07	1.10136E-07	4.41839E-05
11	1.10356E-07	1.10383E-07	1.10404E-07	1.10349E-07	1.10252E-07	1.10160E-07	1.10105E-07	4.41729E-05
12	1.10141E-07	1.10193E-07	1.10269E-07	1.10197E-07	1.10108E-07	1.10049E-07	1.10006E-07	4.41912E-05
13	1.10046E-07	1.10146E-07	1.10357E-07	1.10339E-07	1.10227E-07	1.10113E-07	1.10042E-07	4.41607E-05
14	1.09612E-07	1.09786E-07	1.10225E-07	1.10263E-07	1.10154E-07	1.10063E-07	1.09999E-07	4.42116E-05
15	1.09013E-07	1.09309E-07	1.10188E-07	1.10416E-07	1.10324E-07	1.10191E-07	1.10088E-07	4.41266E-05
16	1.07637E-07	1.08115E-07	1.09704E-07	1.10235E-07	1.10215E-07	1.10096E-07	1.10010E-07	4.42684E-05
17	1.05446E-07	1.06189E-07	1.08959E-07	1.09984E-07	1.10072E-07	1.10036E-07	1.09978E-07	4.40320E-05

TABLE 6-2 (CONTINUED)

18	1.02122E-07	1.03233E-07	1.07878E-07	1.10055E-07	1.11172E-07	1.10059E-07	1.09979E-07	4.44262E-05
19	9.64166E-08	9.81878E-08	1.05572E-07	1.09691E-07	1.11179E-07	1.10109E-07	1.10010E-07	4.37659E-05
20	8.81911E-08	9.02683E-08	1.01331E-07	1.09384E-07	1.10289E-07	1.10131E-07	1.10006E-07	4.48645E-05
21	7.58756E-08	7.83866E-08	9.36042E-08	1.07739E-07	1.10115E-07	1.10163E-07	1.09998E-07	4.30352E-05
22	5.92411E-08	6.19112E-08	8.04430E-08	1.05362E-07	1.10171E-07	1.10130E-07	1.09944E-07	4.60824E-05
23	3.93659E-08	4.17106E-08	6.05153E-08	9.63434E-08	1.08920E-07	1.10140E-07	1.09992E-07	4.10070E-05
24	1.94113E-08	2.08958E-08	3.47648E-08	8.04104E-08	1.07574E-07	1.10060E-07	1.10110E-07	4.94669E-05
25	5.21091E-09	5.68534E-09	1.07093E-08	3.72496E-08	1.00683E-07	1.09410E-07	1.10115E-07	3.53151E-05

	17	18	19	20	21	22	23	24
1	4.41777E-05	4.41809E-05	5.43892E-05	5.43891E-05	5.43886E-05	5.43898E-05	5.43890E-05	8.49182E-05
2	4.41827E-05	4.41788E-05	5.43893E-05	5.43893E-05	5.43903E-05	5.43891E-05	5.43892E-05	8.49172E-05
3	4.41756E-05	4.41806E-05	5.43892E-05	5.43892E-05	5.43876E-05	5.43893E-05	5.43893E-05	8.49173E-05
4	4.41656E-05	4.41792E-05	5.43892E-05	5.43892E-05	5.43916E-05	5.43872E-05	5.43892E-05	8.49177E-05
5	4.41717E-05	4.41802E-05	5.43892E-05	5.43892E-05	5.43857E-05	5.43891E-05	5.43893E-05	8.49175E-05
6	4.41910E-05	4.41795E-05	5.43892E-05	5.43892E-05	5.43943E-05	5.43895E-05	5.43892E-05	8.49175E-05
7	4.41641E-05	4.41799E-05	5.43892E-05	5.43892E-05	5.43818E-05	5.43887E-05	5.43893E-05	8.49175E-05
8	4.42016E-05	4.41794E-05	5.43892E-05	5.43892E-05	5.44001E-05	5.43901E-05	5.43891E-05	8.49175E-05
9	4.41493E-05	4.41797E-05	5.43892E-05	5.43892E-05	5.43733E-05	5.43880E-05	5.43894E-05	8.49174E-05
10	4.42222E-05	4.41800E-05	5.43892E-05	5.43892E-05	5.44125E-05	5.43910E-05	5.43890E-05	8.49174E-05
11	4.41207E-05	4.41795E-05	5.43892E-05	5.43892E-05	5.43550E-05	5.43868E-05	5.43895E-05	8.49175E-05
12	4.42621E-05	4.41802E-05	5.43892E-05	5.43892E-05	5.44395E-05	5.43923E-05	5.43888E-05	8.49174E-05
13	4.40650E-05	4.41793E-05	5.43892E-05	5.43893E-05	5.43152E-05	5.43845E-05	5.43899E-05	8.49175E-05
14	4.43397E-05	4.41805E-05	5.43892E-05	5.43892E-05	5.44993E-05	5.43953E-05	5.43883E-05	8.49173E-05
15	4.39568E-05	4.41789E-05	5.43893E-05	5.43892E-05	5.42283E-05	5.43800E-05	5.43905E-05	8.49173E-05
16	4.44907E-05	4.41810E-05	5.43891E-05	5.43893E-05	5.46270E-05	5.44022E-05	5.43874E-05	8.49174E-05
17	4.37461E-05	4.41783E-05	5.43893E-05	5.43886E-05	5.40374E-05	5.43710E-05	5.43918E-05	8.49175E-05
18	4.47847E-05	4.41817E-05	5.43894E-05	5.43916E-05	5.49102E-05	5.44148E-05	5.43856E-05	8.49170E-05
19	4.33355E-05	4.41774E-05	5.43872E-05	5.43800E-05	5.35165E-05	5.43534E-05	5.43943E-05	8.49162E-05
20	4.53574E-05	4.41826E-05	5.43989E-05	5.44222E-05	5.55373E-05	5.44392E-05	5.43824E-05	8.49129E-05
21	4.25361E-05	4.41761E-05	5.43398E-05	5.42691E-05	5.26776E-05	5.43212E-05	5.43981E-05	8.49054E-05
22	4.64746E-05	4.41849E-05	5.46116E-05	5.48140E-05	5.69540E-05	5.44769E-05	5.43775E-05	8.48196E-05
23	4.09742E-05	4.41750E-05	5.33801E-05	5.28680E-05	5.95046E-05	5.42925E-05	5.44005E-05	8.41407E-05
24	4.86574E-05	4.41867E-05	5.90249E-05	5.98188E-05	6.03710E-05	5.44476E-05	5.43891E-05	7.87800E-05
25	3.78824E-05	4.41666E-05	3.31452E-05	3.47430E-05	-4.48776E-03	5.45007E-05	5.43623E-05	3.70074E-05

	25	26	27	28	29	30
1	8.49161E-05	8.49181E-05	8.49179E-05	8.49178E-05	8.49177E-05	8.49176E-05
2	8.49178E-05	8.49178E-05	8.49178E-05	8.49175E-05	8.49172E-05	8.49171E-05
3	8.49173E-05	8.49174E-05	8.49176E-05	8.49177E-05	8.49177E-05	8.49176E-05
4	8.49173E-05	8.49174E-05	8.49177E-05	8.49177E-05	8.49179E-05	8.49180E-05
5	8.49175E-05	8.49175E-05	8.49174E-05	8.49176E-05	8.49177E-05	8.49177E-05
6	8.49175E-05	8.49175E-05	8.49179E-05	8.49178E-05	8.49177E-05	8.49177E-05
7	8.49175E-05	8.49175E-05	8.49171E-05	8.49175E-05	8.49177E-05	8.49177E-05
8	8.49175E-05	8.49175E-05	8.49185E-05	8.49174E-05	8.49176E-05	8.49177E-05
9	8.49175E-05	8.49175E-05	8.49160E-05	8.49173E-05	8.49178E-05	8.49177E-05
10	8.49175E-05	8.49175E-05	8.49203E-05	8.49181E-05	8.49175E-05	8.49177E-05

TABLE 6-2 (CONTINUED)

11	8.49175E-05	8.49175E-05	8.49129E-05	8.49169E-05	8.49181E-05	8.49177E-05
12	8.49174E-05	8.49175E-05	8.49258E-05	8.49190E-05	8.49173E-05	8.49180E-05
13	8.49176E-05	8.49177E-05	8.49032E-05	8.49155E-05	8.49185E-05	8.49176E-05
14	8.49173E-05	8.49174E-05	8.49430E-05	8.49212E-05	8.49164E-05	8.49181E-05
15	8.49173E-05	8.49174E-05	8.48726E-05	8.49118E-05	8.49200E-05	8.49173E-05
16	8.49174E-05	8.49174E-05	8.49975E-05	8.49275E-05	8.49139E-05	8.49186E-05
17	8.49176E-05	8.49177E-05	8.47750E-05	8.49010E-05	8.49243E-05	8.49162E-05
18	8.49171E-05	8.49173E-05	8.51730E-05	8.49461E-05	8.49065E-05	8.49205E-05
19	8.49165E-05	8.49174E-05	8.44588E-05	8.48689E-05	8.49371E-05	8.49131E-05
20	8.49137E-05	8.49156E-05	8.57440E-05	8.50016E-05	8.48842E-05	8.49253E-05
21	8.49112E-05	8.49148E-05	8.34238E-05	8.47727E-05	8.49756E-05	8.49034E-05
22	8.48555E-05	8.49441E-05	8.76352E-05	8.51663E-05	8.48154E-05	8.49379E-05
23	8.43588E-05	8.45254E-05	7.99422E-05	8.44973E-05	8.50843E-05	8.48730E-05
24	7.98079E-05	8.69114E-05	9.49277E-05	8.52926E-05	8.48071E-05	8.49365E-05
25	3.78482E-05	4.48715E-05	6.35230E-05	8.49303E-05	8.48237E-05	8.49587E-05

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TABLE 6-2 (CONTINUED)

SURFACE FLUX,SIDE GROUP NO.= 1

	1	2	3	4	5	6	7	8
1	8.18351E-07	1.30427E-06	6.02517E-07	1.29126E-06	2.70283E-07	3.21831E-07	1.86508E-07	1.55284E-07
2	2.40090E-06	1.82349E-06	2.39735E-06	3.29373E-06	5.85135E-07	8.74691E-07	4.87045E-07	3.34176E-07
3	8.36712E-06	8.59724E-06	8.25721E-06	8.39882E-06	1.09269E-06	2.80546E-06	3.09824E-06	4.25454E-06
4	2.85665E-05	2.85115E-05	2.84467E-05	2.14049E-05	2.65375E-05	3.24929E-05	2.94858E-05	3.09017E-05
5	2.20943E-05	2.21003E-05	2.20444E-05	2.71952E-05	2.71952E-05	2.71994E-05	2.68189E-05	2.72255E-05

	9	10	11	12	13	14	15	16
1	1.10455E-07	1.10454E-07	1.10452E-07	1.10447E-07	1.09683E-07	1.09410E-07	1.10116E-07	-5.42339E-10
2	5.79171E-07	5.79170E-07	5.79164E-07	5.79151E-07	5.42777E-07	5.76287E-07	5.78961E-07	-1.88006E-09
3	3.05015E-06	3.05017E-06	3.05019E-06	3.05019E-06	2.93099E-06	3.04370E-06	3.05335E-06	-5.95973E-09
4	1.61034E-05	1.61034E-05	1.61035E-05	1.61035E-05	1.58035E-05	1.60774E-05	1.61128E-05	-3.01455E-08
5	4.24703E-05	4.24703E-05	4.24703E-05	4.24704E-05	4.10889E-05	4.24970E-05	4.24004E-05	2.20751E-05

	17	18	19	20	21	22	23	24
1	-5.37659E-10	-3.24107E-10	-2.67283E-10	-2.67334E-10	-2.62735E-10	-1.33122E-10	-1.32911E-10	3.05973E-10
2	-1.86319E-09	-1.18108E-09	-8.24174E-10	-8.27008E-10	-8.13872E-10	-4.38953E-10	-4.62796E-10	1.30535E-09
3	-5.75497E-09	-4.44563E-09	-2.38255E-09	-2.32804E-09	-2.18576E-09	-1.16457E-09	-5.35037E-10	5.08211E-09
4	-2.99932E-08	-1.99449E-08	-9.04345E-09	-8.97732E-09	-8.81435E-09	-2.83407E-09	8.13283E-09	3.49841E-08
5	2.20812E-05	2.20359E-05	2.71901E-05	2.71901E-05	2.71934E-05	2.68191E-05	2.72308E-05	4.24899E-05

	25	26	27	28	29	30
1	3.06712E-10	3.10295E-10	3.34150E-10	2.61907E-10	3.58021E-10	3.76089E-10
2	1.30772E-09	1.31309E-09	1.29719E-09	1.00646E-09	1.38271E-09	1.43355E-09
3	5.08715E-09	5.09971E-09	5.12110E-09	5.34173E-09	7.49862E-09	8.00697E-09
4	3.49919E-08	3.49927E-08	3.49455E-08	2.92067E-08	4.46893E-08	5.01301E-08
5	4.24899E-05	4.24899E-05	4.24900E-05	4.11045E-05	4.29206E-05	4.24258E-05

TABLE 6-2 (CONTINUED)

POINT FLUX,TOP GROUP NO.= 1

	1	2	3	4	5	6	7	8
1	0.	1.00338E-08	1.00906E-08	0.	0.	0.	0.	0.
2	0.	9.77664E-09	1.03574E-08	0.	0.	0.	0.	0.
3	0.	9.26507E-09	1.08438E-08	0.	0.	0.	0.	0.
4	0.	8.62377E-09	1.14982E-08	0.	0.	0.	0.	0.
5	0.	7.83733E-09	1.22588E-08	0.	0.	0.	0.	0.
6	0.	6.73409E-09	1.33446E-08	0.	0.	0.	0.	0.
7	0.	5.91812E-09	1.41162E-08	0.	0.	0.	0.	0.
8	0.	5.55747E-09	1.44994E-08	0.	0.	0.	0.	0.
9	0.	5.30161E-09	1.46417E-08	0.	0.	0.	0.	0.
10	0.	5.01968E-09	1.49760E-08	0.	0.	0.	0.	0.
11	0.	4.58972E-09	1.53525E-08	0.	0.	0.	0.	0.
12	0.	4.26782E-09	1.56384E-08	0.	0.	0.	0.	0.
13	0.	3.72264E-09	1.61377E-08	0.	0.	0.	0.	0.
14	0.	3.27709E-09	1.65243E-08	0.	0.	0.	0.	0.
15	0.	2.65406E-09	1.71051E-08	0.	0.	0.	0.	0.
16	0.	2.12436E-09	1.76200E-08	0.	0.	0.	0.	0.
17	0.	1.58413E-09	1.80896E-08	0.	0.	0.	0.	0.
18	0.	1.42493E-09	1.81429E-08	0.	0.	0.	0.	0.
19	0.	1.10039E-09	1.85479E-08	0.	0.	0.	0.	0.
20	0.	8.30269E-10	1.86994E-08	0.	0.	0.	0.	0.
21	0.	6.77626E-10	1.87718E-08	0.	0.	0.	0.	0.
22	0.	2.96299E-10	1.91342E-08	0.	0.	0.	0.	0.
23	0.	6.11446E-11	1.92085E-08	0.	0.	0.	0.	0.
24	0.	5.57541E-12	1.93252E-08	0.	0.	0.	0.	0.
25	0.	0.	1.94717E-08	0.	0.	0.	0.	0.
26	0.	0.	1.93754E-08	0.	0.	0.	0.	0.
27	0.	0.	1.94546E-08	0.	0.	0.	0.	0.
28	0.	0.	1.86545E-08	0.	0.	0.	0.	0.
29	0.	0.	1.77728E-08	0.	0.	0.	0.	0.
30	0.	0.	1.67367E-08	0.	0.	0.	0.	0.
31	0.	0.	1.58778E-08	0.	0.	0.	0.	0.
32	0.	0.	1.50087E-08	0.	0.	0.	0.	0.
33	0.	0.	1.39011E-08	0.	0.	0.	0.	0.
34	0.	0.	1.31292E-08	0.	0.	0.	0.	0.
35	0.	0.	1.19831E-08	0.	0.	0.	0.	7.26629E-10
36	0.	0.	6.74263E-09	0.	0.	0.	0.	3.58670E-09
37	0.	0.	3.43573E-09	0.	0.	0.	0.	6.45279E-09

	9	10	11	12	13	14	15	16
1	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.

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TABLE 6-2 (CONTINUED)

6	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.

	17	18	19	20	21	22	23	24
1	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.

TABLE 6-2 (CONTINUED)

14	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.

	25	26	27	28	29	30
1	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.

TABLE 6-2 (CONTINUED)

22	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.

TABLE 6-2 (CONTINUED)

POINT FLUX,SIDE GROUP NO.= 1

	1	2	3	4	5	6	7	8
1	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	1.09300E-09	0.	0.	0.	0.	0.
27	0.	0.	4.78813E-09	0.	0.	0.	0.	0.
28	0.	0.	8.92921E-09	0.	0.	0.	0.	0.
29	0.	0.	1.29920E-08	0.	0.	0.	0.	0.
30	0.	0.	1.67431E-08	0.	0.	0.	0.	0.
31	0.	0.	2.00522E-08	0.	0.	0.	0.	0.
32	0.	0.	2.28479E-08	0.	0.	0.	0.	0.
33	0.	0.	2.51016E-08	0.	0.	0.	0.	0.
34	0.	0.	2.68167E-08	0.	0.	0.	0.	0.
35	0.	0.	2.80208E-08	0.	0.	0.	0.	0.
36	0.	0.	2.87577E-08	0.	0.	0.	0.	0.
37	0.	0.	2.89761E-08	0.	0.	0.	0.	0.

	9	10	11	12	13	14	15	16
1	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.

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TABLE 6-2 (CONTINUED)

6	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.

	17	18	19	20	21	22	23	24
1	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.

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TABLE 6-2 (CONTINUED)

14	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.

	25	26	27	28	29	30
1	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.

TABLE 6-2 (CONTINUED)

22	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.

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TABLE 6-2 (CONTINUED)

POINT FLUX,TOTAL GROUP NO.= 1

	1	2	3	4	5	6	7	8
1	0.	1.00338E-08	1.00906E-08	0.	0.	0.	0.	0.
2	0.	9.77664E-09	1.03574E-08	0.	0.	0.	0.	0.
3	0.	9.26507E-09	1.04438E-08	0.	0.	0.	0.	0.
4	0.	8.62377E-09	1.14982E-08	0.	0.	0.	0.	0.
5	0.	7.93733E-09	1.22588E-08	0.	0.	0.	0.	0.
6	0.	6.73409E-09	1.33446E-08	0.	0.	0.	0.	0.
7	0.	5.91512E-09	1.41162E-08	0.	0.	0.	0.	0.
8	0.	5.55747E-09	1.44994E-08	0.	0.	0.	0.	0.
9	0.	5.30161E-09	1.46417E-08	0.	0.	0.	0.	0.
10	0.	5.01968E-09	1.49760E-08	0.	0.	0.	0.	0.
11	0.	4.58972E-09	1.53525E-08	0.	0.	0.	0.	0.
12	0.	4.25782E-09	1.56384E-08	0.	0.	0.	0.	0.
13	0.	3.72264E-09	1.61377E-08	0.	0.	0.	0.	0.
14	0.	3.27709E-09	1.65243E-08	0.	0.	0.	0.	0.
15	0.	2.65406E-09	1.71051E-08	0.	0.	0.	0.	0.
16	0.	2.12436E-09	1.76206E-08	0.	0.	0.	0.	0.
17	0.	1.58413E-09	1.80896E-08	0.	0.	0.	0.	0.
18	0.	1.42493E-09	1.81429E-08	0.	0.	0.	0.	0.
19	0.	1.10039E-09	1.85479E-08	0.	0.	0.	0.	0.
20	0.	8.30269E-10	1.86994E-08	0.	0.	0.	0.	0.
21	0.	6.77626E-10	1.87718E-08	0.	0.	0.	0.	0.
22	0.	2.96299E-10	1.91342E-08	0.	0.	0.	0.	0.
23	0.	6.11446E-11	1.92065E-08	0.	0.	0.	0.	0.
24	0.	5.57541E-12	1.93252E-08	0.	0.	0.	0.	0.
25	0.	0.	1.94717E-08	0.	0.	0.	0.	0.
26	0.	0.	2.04684E-08	0.	0.	0.	0.	0.
27	0.	0.	2.42427E-08	0.	0.	0.	0.	0.
28	0.	0.	2.75837E-08	0.	0.	0.	0.	0.
29	0.	0.	3.07648E-08	0.	0.	0.	0.	0.
30	0.	0.	3.34798E-08	0.	0.	0.	0.	0.
31	0.	0.	3.59299E-08	0.	0.	0.	0.	0.
32	0.	0.	3.76566E-08	0.	0.	0.	0.	0.
33	0.	0.	3.90026E-08	0.	0.	0.	0.	0.
34	0.	0.	3.99459E-08	0.	0.	0.	0.	0.
35	0.	0.	4.00038E-08	0.	0.	0.	0.	7.26629E-10
36	0.	0.	3.65004E-08	0.	0.	0.	0.	3.59670E-09
37	0.	0.	3.24119E-08	0.	0.	0.	0.	6.45279E-09

	9	10	11	12	13	14	15	16
1	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.

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TABLE 6-2 (CONTINUED)

6	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.

	17	18	19	20	21	22	23	24
1	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.

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14	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.

	25	26	27	28	29	30
1	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.

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TABLE 6-2 (CONTINUED)

22	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.

DISTRIBUTIONS ON PLANE OR RING FOR GROUP 1

	FLUX			VERTICAL CURRENTS			
	TOTAL	TOP	SIDE	TOP(MAP)	TOP(DOT)	SIDE(MAP)	SIDE(DOT)
1	8.05560E-10	8.05560E-10	0.	8.03741E-10	7.51150E-10	0.	0.
2	8.05959E-10	8.05959E-10	0.	8.04128E-10	7.51532E-10	0.	0.
3	8.04982E-10	8.04982E-10	0.	8.03124E-10	7.50621E-10	0.	0.
4	8.05543E-10	8.05543E-10	0.	8.03646E-10	7.51144E-10	0.	0.
5	8.04565E-10	8.04565E-10	0.	8.02615E-10	7.50232E-10	0.	0.
6	8.03930E-10	8.03930E-10	0.	8.01915E-10	7.49640E-10	0.	0.
7	8.02238E-10	8.02238E-10	0.	8.00145E-10	7.48063E-10	0.	0.
8	8.03231E-10	8.03231E-10	0.	8.01046E-10	7.48948E-10	0.	0.
9	7.98798E-10	7.98798E-10	0.	7.9651[illegible]E-10	7.44655E-10	0.	0.
10	8.01007E-10	8.01007E-10	0.	7.98602E-10	7.46914E-10	0.	0.
11	7.99004E-10	7.99004E-10	0.	7.96468E-10	7.45047E-10	0.	0.
12	7.97705E-10	7.97705E-10	0.	7.95028E-10	7.43837E-10	0.	0.
13	7.96030E-10	7.96030E-10	0.	7.93198E-10	7.42274E-10	0.	0.
14	7.93840E-10	7.93840E-10	0.	7.90842E-10	7.40232E-10	0.	0.
15	7.92331E-10	7.92331E-10	0.	7.89155E-10	7.38825E-10	0.	0.
16	7.91956E-10	7.91956E-10	0.	7.88587E-10	7.38475E-10	0.	0.
17	7.89316E-10	7.89316E-10	0.	7.85746E-10	7.36013E-10	0.	0.
18	7.85304E-10	7.85304E-10	0.	7.81515E-10	7.32272E-10	0.	0.
19	7.88747E-10	7.88747E-10	0.	7.84729E-10	7.35483E-10	0.	0.
20	7.84249E-10	7.84249E-10	0.	7.7999[illegible]E-10	7.312[illegible]E-10	0.	0.
21	7.81297E-10	7.81297E-10	0.	7.76787E-10	7.28536E-10	0.	0.
22	7.80794E-10	7.80794E-10	0.	7.76028E-10	7.28066E-10	0.	0.
23	7.74644E-10	7.74644E-10	0.	7.69604E-10	7.22332E-10	0.	0.
24	7.77367E-10	7.77367E-10	0.	7.72048E-10	7.24871E-10	0.	0.

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TABLE 6-2 (CONTINUED)

25	7.83291E-10	7.83291E-10	0.	7.77673E-10	7.30395E-10	0.	0.
26	8.25409E-10	7.81719E-10	4.36907E-11	7.73829E-10	7.28929E-10	4.36532E-11	-4.07402E-11
27	9.52643E-1	7.94551E-10	1.92092E-10	7.76992E-10	7.37165E-10	1.91237E-10	-1.7912 E-10
28	1.12585E-09	7.65429E-10	3.00421E-10	7.45035E-10	7.13739E-10	3.56621E-10	-3.36082E-10
29	1.26688E-09	7.37995E-10	5.28888E-10	7.09025E-10	6.88157E-10	5.18684E-10	-4.93172E-10
30	1.39372E-09	7.04759E-10	6.88966E-10	6.68443E-10	6.57166E-10	6.66699E-10	-6.42439E-10
31	1.51508E-09	6.79251E-10	8.35824E-10	6.34137E-10	6.33341E-10	8.00857E-10	-7.79381E-10
32	1.62.00E-09	6.53410E-10	9.65587E-10	5.99427E-10	6.09285E-10	9.12515E-10	-9.01313E-10
33	1.69656E-09	6.16853E-10	1.07971E-09	5.55191E-10	5.75196E-10	1.00252E-09	-1.00680E-09
34	1.76993E-09	5.95264E-10	1.17467E-09	5.24364E-10	5.55066E-10	1.07102E-09	-1.09534E-09
35	1.83675E-09	5.87038E-10	1.25171E-09	5.05128E-10	5.38682E-10	1.11911E-09	-1.16718E-09
36	1.78807E-09	4.76410E-10	1.31166E-09	4.00294E-10	4.00672E-10	1.14855E-09	-1.22308E-09
37	1.80639E-09	4.55711E-10	1.35068E-09	3.72902E-10	3.45384E-10	1.15727E-09	-1.25947E-09

TABLE 6-2 (CONTINUED)

SURFACE FLUX,TOP GROUP NO.= 2

	1	2	3	4	5	6	7	8
1	2.19015E-07	1.40670E-07	4.49027E-07	1.13919E-06	1.13969E-06	1.12639E-06	1.13914E-06	1.13594E-06
2	3.55510E-07	3.79860E-07	1.26396E-07	1.13563E-06	1.13603E-06	1.04942E-06	1.09355E-06	1.12757E-06
3	1.64740E-07	2.26474E-07	4.27023E-07	1.13029E-06	1.13025E-06	3.79813E-07	1.77422E-07	1.01367E-06
4	3.91797E-07	4.76289E-07	1.22714E-07	1.12790E-06	1.12776E-06	3.35004E-07	4.38641E-07	9.83774E-07
5	1.13416E-07	2.24660E-07	3.95364E-07	1.12853E-06	1.12940E-06	2.91433E-07	1.17819E-07	9.81631E-07
6	4.35010E-07	3.43128E-07	1.49443E-07	1.12720E-06	1.12709E-06	2.82901E-07	3.95505E-07	1.00666E-06
7	8.68413E-08	2.24515E-07	3.67971E-07	1.12820E-06	1.12811E-06	2.41135E-07	9.59091E-08	1.01914E-06
8	4.11602E-07	3.59427E-07	1.72818E-07	1.12612E-06	1.12595E-06	2.53243E-07	2.71834E-08	1.02535E-06
9	1.97387E-07	2.34324E-07	3.40841E-07	1.12810E-06	1.12802E-06	2.04124E-07	7.35362E-08	1.03447E-06
10	4.22605E-07	3.79958E-07	1.95536E-07	1.12611E-06	1.12596E-06	2.40534E-07	9.70933E-09	1.04356E-06
11	1.82399E-07	1.39[illegible]61E-07	3.18242E-07	1.12774E-06	1.12762E-06	1.70894E-07	8.47737E-09	1.05124E-06
12	3.85863E-07	3.05011E-07	2.13264E-07	1.12635E-06	1.12624E-06	2.41512E-07	1.29577E-07	1.05495E-06
13	1.67038E-07	2.99025E-07	3.04485E-07	1.12736E-06	1.12734E-06	1.36097E-07	4.48463E-08	1.0[illegible]145E-06
14	3.46947E-07	1.64914E-07	2.25476E-07	1.12572E-06	1.12572E-06	4.04279E-07	4.98221E-08	1.06193E-06
15	1.49102E-07	3.94413E-07	2.91845E-07	1.12626E-06	1.12642E-06	4.19049E-07	1.32518E-07	1.06647E-06
16	3.04021E-07	1.33910E-07	2.36930E-07	1.12527E-06	1.12576E-06	3.94800E-07	1.48790E-07	1.06991E-06
17	2.69435E-07	3.45424E-07	2.82363E-07	1.12358E-06	1.12480E-06	4.18243E-07	6.00231E-09	1.07229E-06
18	1.28338E-07	2.48503E-07	2.45944E-07	1.12103E-06	1.12394E-06	2.39316E-07	7.77173E-08	1.08241E-06
19	4.14215E-07	4.82954E-07	2.79219E-07	1.11079E-06	1.11729E-06	9.48209E-08	2.00080E-08	1.08589E-06
20	2.32299E-07	2.68724E-07	2.54834E-07	1.08979E-06	1.10306E-06	2.32139E-07	9.73032E-08	1.08530E-06
21	5.11517E-07	2.22478E-07	2.70852E-07	1.04249E-06	1.00773E-06	8.11959E-08	3.45235E-09	1.08521E-06
22	1.44605E-07	3.73038E-07	2.53239E-07	9.47626E-07	9.90539E-07	3.42471E-07	1.27048E-07	1.08334E-06
23	1.01273E-07	2.21361E-07	2.66349E-07	7.78314E-07	8.39774E-07	2.80090E-07	9.88456E-08	1.08753E-06
24	5.81565E-08	9.48770E-08	2.55013E-07	5.07184E-07	5.75558E-07	9.75234E-07	3.61771E-07	1.09457E-06
25	1.87819E-08	2.77776E-08	2.49218E-07	1.76855E-07	2.11571E-07	5.32080E-07	1.12707E-07	1.08439E-06

	9	10	11	12	13	14	15	16
1	1.28172E-07	1.28242E-07	1.28521E-07	1.29037E-07	1.29536E-07	1.29947E-07	1.30477E-07	4.43827E-05
2	1.26659E-07	1.26094E-07	1.26974E-07	1.27761E-07	1.28849E-07	1.29584E-07	1.30203E-07	4.43794E-05
3	1.24814E-07	1.24774E-07	1.24605E-07	1.24445E-07	1.24670E-07	1.25246E-07	1.25960E-07	4.43762E-05
4	1.23315E-07	1.23245E-07	1.22837E-07	1.22169E-07	1.21758E-07	1.21946E-07	1.22393E-07	4.43755E-05
5	1.23843E-07	1.23781E-07	1.23410E-07	1.22803E-07	1.21901E-07	1.21197E-07	1.20984E-07	4.43768E-05
6	1.22663E-07	1.22594E-07	1.22201E-07	1.21559E-07	1.20959E-07	1.2[illegible]51[illegible]E-07	1.20247E-07	4.43787E-05
7	1.23447E-07	1.23390E-07	1.23050E-07	1.22591E-07	1.21859E-07	1.20944E-07	1.20363E-07	4.43765E-05
8	1.22012E-07	1.21935E-07	1.21419E-07	1.20487E-07	1.19747E-07	1.19399E-07	1.19082E-07	4.43794E-05
9	1.23262E-07	1.23210E-07	1.22873E-07	1.22395E-07	1.21461E-07	1.20354E-07	1.19564E-07	4.43751E-05
10	1.21649E-07	1.21787E-07	1.21330E-07	1.20505E-07	1.19845E-07	1.19407E-07	1.18999E-07	4.43623E-05
11	1.22065E-07	1.22023E-07	1.22516E-07	1.22012E-07	1.21137E-07	1.20163E-07	1.19530E-07	4.43703E-05
12	1.21829E-07	1.21797E-07	1.21448E-07	1.20730E-07	1.20038E-07	1.19518E-07	1.19033E-07	4.43904E-05
13	1.22354E-07	1.22363E-07	1.22214E-07	1.21940E-07	1.21074E-07	1.20165E-07	1.19566E-07	4.43569E-05
14	1.20688E-07	1.20931E-07	1.20846E-07	1.20368E-07	1.19956E-07	1.19598E-07	1.19253E-07	4.44127E-05
15	1.21163E-07	1.21280E-07	1.21465E-07	1.21131E-07	1.20485E-07	1.19669E-07	1.19448E-07	4.43202E-05
16	1.20062E-07	1.20292E-07	1.20898E-07	1.20745E-07	1.20256E-07	1.19730E-07	1.19353E-07	4.44733E-05
17	1.18632E-07	1.19239E-07	1.20584E-07	1.20611E-07	1.20139E-07	1.19777E-07	1.19479E-07	4.42205E-05

TABLE 6-2 (CONTINUED)

18	1.17411E-07	1.18096E-07	1.20847E-07	1.21590E-07	1.21306E-07	1.20534E-07	1.20072E-07	4.45370E-05
19	1.12575E-07	1.13627E-07	1.16410E-07	1.20722E-07	1.20773E-07	1.20393E-07	1.20053E-07	4.39514E-05
20	1.06409E-07	1.07927E-07	1.15773E-07	1.21140E-07	1.21378E-07	1.20818E-07	1.20403E-07	4.50771E-05
21	9.42216E-08	9.62167E-08	1.07910E-07	1.18142E-07	1.20244E-07	1.21278E-07	1.20076E-07	4.32266E-05
22	7.84216E-08	8.07500E-08	9.61975E-08	1.15003E-07	1.19111E-07	1.19839E-07	1.19992E-07	4.62637E-05
23	5.80342E-08	6.03218E-08	7.81606E-08	1.08093E-07	1.18794E-07	1.20474E-07	1.20923E-07	4.12641E-05
24	3.26449E-08	3.44410E-08	4.98761E-08	9.16870E-08	1.17179E-07	1.21349E-07	1.22558E-07	4.94824E-05
25	9.67853E-09	1.04714E-08	1.78519E-08	4.62425E-08	1.04358E-07	1.17819E-07	1.21700E-07	3.53350E-05

	17	18	19	20	21	22	23	24
1	4.43800E-05	4.43828E-05	5.42138E-05	5.42138E-05	5.42131E-05	5.42134E-05	5.42136E-05	8.21466E-05
2	4.43839E-05	4.43808E-05	5.42109E-05	5.42112E-05	5.42135E-05	5.42136E-05	5.42140E-05	8.21395E-05
3	4.43716E-05	4.43814E-05	5.42118E-05	5.42118E-05	5.42098E-05	5.42134E-05	5.42144E-05	8.21271E-05
4	4.43652E-05	4.43768E-05	5.42142E-05	5.42141E-05	5.42164E-05	5.42126E-05	5.42131E-05	8.21260E-05
5	4.43679E-05	4.43793E-05	5.42127E-05	5.42127E-05	5.42084E-05	5.42134E-05	5.42143E-05	8.21245E-05
6	4.43912E-05	4.43780E-05	5.42137E-05	5.42136E-05	5.42197E-05	5.42135E-05	5.42135E-05	8.21240E-05
7	4.43597E-05	4.43784E-05	5.42130E-05	5.42130E-05	5.42039E-05	5.42128E-05	5.42141E-05	8.21230E-05
8	4.44026E-05	4.43784E-05	5.42135E-05	5.42134E-05	5.42264E-05	5.42143E-05	5.42134E-05	8.21223E-05
9	4.43438E-05	4.43780E-05	5.42133E-05	5.42133E-05	5.41943E-05	5.42120E-05	5.42141E-05	8.21221E-05
10	4.44248E-05	4.43786E-05	5.42133E-05	5.42132E-05	5.42406E-05	5.42154E-05	5.42132E-05	8.21217E-05
11	4.43132E-05	4.43778E-05	5.42135E-05	5.42135E-05	5.41738E-05	5.42107E-05	5.42142E-05	8.21215E-05
12	4.44671E-05	4.43787E-05	5.42130E-05	5.42130E-05	5.42705E-05	5.42172E-05	5.42129E-05	8.21213E-05
13	4.42548E-05	4.43775E-05	5.42138E-05	5.42139E-05	5.41303E-05	5.42083E-05	5.42145E-05	8.21216E-05
14	4.45477E-05	4.43790E-05	5.42127E-05	5.42125E-05	5.43340E-05	5.42205E-05	5.42124E-05	8.21206E-05
15	4.41437E-05	4.43771E-05	5.42143E-05	5.42144E-05	5.40379E-05	5.42035E-05	5.42152E-05	8.21215E-05
16	4.47013E-05	4.43797E-05	5.42118E-05	5.42119E-05	5.44689E-05	5.42273E-05	5.42115E-05	8.21200E-05
17	4.39317E-05	4.43761E-05	5.42153E-05	5.42147E-05	5.38409E-05	5.41943E-05	5.42163E-05	8.21221E-05
18	4.49940E-05	4.43910E-05	5.42103E-05	5.42129E-05	5.47568E-05	5.42403E-05	5.42100E-05	8.21183E-05
19	4.35271E-05	4.43742E-05	5.42146E-05	5.42060E-05	5.34191E-05	5.41741E-05	5.42180E-05	8.21214E-05
20	4.55527E-05	4.43938E-05	5.42172E-05	5.42453E-05	5.53761E-05	5.42652E-05	5.42080E-05	8.21125E-05
21	4.27532E-05	4.43696E-05	5.41609E-05	5.40815E-05	5.25032E-05	5.41430E-05	5.42192E-05	8.21175E-05
22	4.66226E-05	4.43914E-05	5.44430E-05	5.46603E-05	5.67381E-05	5.43048E-05	5.42075E-05	8.20374E-05
23	4.12575E-05	4.43558E-05	5.31183E-05	5.26250E-05	5.04267E-05	5.41054E-05	5.42133E-05	8.17021E-05
24	4.87012E-05	4.44191E-05	5.87303E-05	5.94880E-05	5.99471E-05	5.43006E-05	5.42276E-05	7.73310E-05
25	3.78681E-05	4.42182E-05	3.30844E-05	3.46660E-05	4.46100E-05	5.41268E-05	5.42506E-05	3.65911E-05

	25	26	27	28	29	30
1	8.21468E-05	8.21468E-05	8.21461E-05	8.21440E-05	8.21419E-05	8.21416E-05
2	8.21386E-05	8.21395E-05	8.21417E-05	8.21436E-05	8.21421E-05	8.21402E-05
3	8.21268E-05	8.21251E-05	8.21221E-05	8.21204E-05	8.21195E-05	8.21186E-05
4	8.21258E-05	8.21242E-05	8.21210E-05	8.21160E-05	8.21091E-05	8.21024E-05
5	8.21243E-05	8.21232E-05	8.21213E-05	8.21204E-05	8.21200E-05	8.21152E-05
6	8.21239E-05	8.21226E-05	8.21209E-05	8.21177E-05	8.21161E-05	8.21175E-05
7	8.21229E-05	8.21223E-05	8.21203E-05	8.21201E-05	8.21181E-05	8.21169E-05
8	8.21222E-05	8.21217E-05	8.21222E-05	8.21200E-05	8.21203E-05	8.21203E-05
9	8.21221E-05	8.21217E-05	8.21187E-05	8.21195E-05	8.21185E-05	8.21186E-05
10	8.21216E-05	8.21213E-05	8.21245E-05	8.21209E-05	8.21195E-05	8.21190E-05

TABLE 6-2 (CONTINUED)

11	8.21215E- 5	8.21213E-05	8.21143E-05	8.21188E-05	8.21193E-05	8.21192E-05
12	8.21213E-05	8.21209E-05	8.21318E-05	8.21222E-05	8.21192E-05	8.21197E-05
13	8.21216E-05	8.21215E-05	8.21015E-05	8.21170E-05	8.21207E-05	8.21142E-05
14	8.21206E-05	8.21203E-05	8.21537E-05	3.21252E-05	8.21184E-05	8.21203E-05
15	8.21215E-05	8.21217E-05	8.20633E-05	8.21124E-05	8.21224E-05	8.21189E-05
16	8.21199E-05	8.21194E-05	8.22194E-05	8.21328E-05	8.21158E-05	8.21210E-05
17	8.21222E- 5	8.21226E-05	8.19493E-05	8.21001E-05	8.21272E-05	8.21180E-05
18	8.21143E- 5	8.21174E-05	8.24176E-05	8.21534E-05	8.21084E-05	8.21234E-05
19	8.21222E- 5	8.21241E-05	8.16047E-05	8.20659E-05	8.21395E-05	8.21142E-05
20	8.21131E-05	8.21139E-05	8.30184E-05	8.22103E-05	8.20871E-05	8.21286E-05
21	8.21213E-05	8.21245E-05	8.05547E-05	8.19711E-05	8.21745E-05	8.21037E-05
22	8.20563E-05	8.21487E-05	8.48776E-05	8.23667E-05	8.20273E-05	8.21403E-05
23	8.18546E-05	8.16536E-05	7.72032E-05	8.17352E-05	8.22554E-05	8.20761E-05
24	7.82842E-05	8.48139E-05	9.16462E-05	8.24735E-05	8.20431E-05	8.21193E-05
25	3.74115E-05	4.42257E-05	6.19431E-05	8.19100E-05	8.21157E-05	8.23284E-05

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TABLE 6-2 (CONTINUED)

SURFACE FLUX,SIDE GROUP NO.= 2

	1	2	3	4	5	6	7	8
1	7.64195E-07	1.21087E-06	5.14169E-07	1.13919E-06	1.13969E-06	1.12639E-06	1.87893E-07	1.08439E-06
2	2.13190E-06	1.52857E-06	1.97934E-06	3.02623E-06	3.02686E-06	2.99655E-06	4.36957E-07	2.93755E-06
3	7.83251E-06	8.09157E-06	7.41461E-06	8.00042E-06	8.00052E-06	7.95620E-06	2.74592E-06	7.92159E-06
4	2.83696E-05	2.83770E-05	2.78143E-05	2.09812E-05	2.09796E-05	2.10508E-05	2.87698E-05	2.12571E-05
5	2.22288E-05	2.22365E-05	2.19547E-05	2.71104E-05	2.71104E-05	2.71140E-05	2.64866E-05	2.71991E-05

	9	10	11	12	13	14	15	16
1	1.28172E-07	1.28242E-07	1.28521E-07	1.29037E-07	1.04358E-07	1.17819E-07	1.21700E-07	-1.09926E-08
2	5.82157E-07	5.82354E-07	5.83091E-07	5.84343E-07	5.13343E-07	5.58795E-07	5.70300E-07	-3.61470E-08
3	2.89226E-06	2.89257E-06	2.89372E-06	2.89545E-06	2.70780E-06	2.85337E-06	2.88739E-06	-1.05979E-07
4	1.52029E-05	1.52024E-05	1.52003E-05	1.51968E-05	1.48163E-05	1.51983E-05	1.52971E-05	-3.05373E-07
5	4.12097E-05	4.12097E-05	4.12097E-05	4.12098E-05	3.96041E-05	4.16760E-05	4.13778E-05	2.20370E-05

	17	18	19	20	21	22	23	24
1	-1.11609E-08	-4.34930E-09	-4.24680E-09	-4.29433E-09	-4.37703E-09	-8.27591E-10	2.57177E-09	9.34265E-09
2	-3.63779E-08	-1.55987E-08	-1.28663E-08	-1.30109E-08	-1.32532E-08	-2.77059E-09	9.18592E-09	3.42166E-08
3	-1.06521E-07	-5.39270E-08	-3.32420E-08	-3.34385E-08	-3.37999E-08	-7.43030E-09	3.07127E-08	1.10612E-07
4	-3.05255E-07	-2.21367E-07	-6.33736E-08	-6.31048E-08	-6.26331E-08	-2.00703E-08	9.71075E-08	4.21476E-07
5	2.20444E-05	2.18680E-05	2.70752E-05	2.70752E-05	2.70795E-05	2.64958E-05	2.72396E-05	4.14071E-05

	25	26	27	28	29	30
1	9.34702E-09	9.35192E-09	9.49497E-09	5.61143E-09	9.64675E-09	1.15431E-08
2	3.42185E-08	3.40307E-08	3.29209E-08	2.10072E-08	3.55416E-08	4.12931E-08
3	1.10592E-07	1.09847E-07	1.06685E-07	7.47803E-08	1.22785E-07	1.39578E-07
4	4.21558E-07	4.22389E-07	4.24224E-07	3.45563E-07	5.12447E-07	5.68239E-07
5	4.14070E-05	4.14071E-05	4.14087E-05	3.97712E-05	4.19124E-05	4.16249E-05

TABLE 6-2 (CONTINUED)

NOT REPRODUCIBLE

POINT FLUX,TOP GROUP NO.= 2

	1	2	3	4	5	6	7	
1	0.	8.21459E-09	8.26387E-09	0.	0.	0.	0.	0.
2	0.	8.90137E-09	8.41763E-09	0.	0.	0.	0.	0.
3	0.	7.57315E- 9	8.89159E-09	0.	0.	0.	0.	0.
4	0.	7.10945E-09	9.36962E-09	0.	0.	0.	0.	0.
5	0.	6.53316E-09	9.92431E-09	0.	0.	0.	0.	0.
6	0.	5.51464E-09	1.09295E-08	0.	0.	0.	0.	0.
7	0.	4.84604E-09	1.15601E-08	0.	0.	0.	0.	0.
8	0.	4.57559E-09	1.18557E-08	0.	0.	0.	0.	0.
9	0.	4.38458E-09	1.19437E-08	0.	0.	0.	0.	0.
10	0.	4.12414E-09	1.22539E-08	0.	0.	0.	0.	0.
11	0.	3.90106E-09	1.25272E-08	0.	0.	0.	0.	0.
12	0.	3.60626E-09	1.27267E-08	0.	0.	0.	0.	0.
13	0.	3.12325E-09	1.31892E-08	0.	0.	0.	0.	0.
14	0.	2.73592E-09	1.35060E-08	0.	0.	0.	0.	0.
15	0.	2.19399E-09	1.40271E-08	0.	0.	0.	0.	0.
16	0.	1.84292E-09	1.43762E-08	0.	0.	0.	0.	0.
17	0.	1.46689E-09	1.47511E-08	0.	0.	0.	0.	0.
18	0.	1.21521E-09	1.49769E-08	0.	0.	0.	0.	0.
19	0.	9.01847E-10	1.52722E-08	0.	0.	0.	0.	0.
20	0.	7.18892E-10	1.53320E-08	0.	0.	0.	0.	0.
21	0.	5.58121E-10	1.54612E-08	0.	0.	0.	0.	0.
22	0.	2.76775E-10	1.56568E-08	0.	0.	0.	0.	0.
23	0.	1.02069E-10	1.57756E-08	0.	0.	0.	0.	0.
24	0.	2.38676E-11	1.58305E-08	0.	0.	0.	0.	0.
25	0.	0.	1.59612E-08	0.	0.	0.	0.	0.
26	0.	0.	1.57441E-08	0.	0.	0.	0.	0.
27	0.	0.	1.56574E-08	0.	0.	0.	0.	0.
28	0.	0.	1.50007E-08	0.	0.	0.	0.	0.
29	0.	0.	1.43100E-08	0.	0.	0.	0.	0.
30	0.	0.	1.34364E-08	0.	0.	0.	0.	0.
31	0.	0.	1.26638E-08	0.	0.	0.	0.	0.
32	0.	0.	1.19352E-08	0.	0.	0.	0.	0.
33	0.	0.	1.10522E-08	0.	0.	0.	0.	0.
34	0.	0.	1.04629E-08	0.	0.	0.	0.	0.
35	0.	0.	1.18855E-08	0.	0.	0.	0.	6.72869E-10
36	0.	0.	6.82207E-09	0.	0.	0.	0.	5.50559E-09
37	0.	0.	4.48492E-09	0.	0.	0.	0.	1.06808E-08

	9	10	11	12	13	14	15	16
1	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.

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TABLE 6-2 (CONTINUED)

6	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.

	17	18	19	20	21	22	23	24
1	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.

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TABLE 6-2 (CONTINUED)

14	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.

	25	26	27	28	29	30
1	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.

TABLE 6-2 (CONTINUED)

22	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.

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TABLE 6-2 (CONTINUED)

POINT FLUX,SIDE GROUP NO.= 2

	1	2	3	4	5	6	7	
1	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	1.05589E-09	0.	0.	0.	0.	0.
27	0.	0.	4.62558E-09	0.	0.	0.	0.	0.
28	0.	0.	8.62613E-09	0.	0.	0.	0.	0.
29	0.	0.	1.25511E-08	0.	0.	0.	0.	0.
30	0.	0.	1.61752E-08	0.	0.	0.	0.	0.
31	0.	0.	1.93722E-08	0.	0.	0.	0.	0.
32	0.	0.	2.20735E-08	0.	0.	0.	0.	0.
33	0.	0.	2.42512E-08	0.	0.	0.	0.	0.
34	0.	0.	2.59067E-08	0.	0.	0.	0.	0.
35	0.	0.	2.70725E-08	0.	0.	0.	0.	0.
36	0.	0.	2.77850E-08	0.	0.	0.	0.	0.
37	0.	0.	2.80306E-08	0.	0.	0.	0.	0.

	9	10	11	12	13	14	15	16
1	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.

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TABLE 6-2 (CONTINUED)

6	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.

	17	18	19	20	21	22	23	24
1	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.

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TABLE 6-2 (CONTINUED)

14	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.

	25	26	27	28	29	30
1	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.

TABLE 6-2 (CONTINUED)

22	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.

TABLE 6-2 (CONTINUED)

POINT FLUX,TOTAL GROUP NO.= 2

	1	2	3	4	5	6	7	
1	0.	8.21459E-09	8.25387E-09	0.	0.	0.	0.	0.
2	0.	8.00037E-09	8.47835E-09	0.	0.	0.	0.	0.
3	0.	7.57315E-09	8.89159E-09	0.	0.	0.	0.	0.
4	0.	7.10945E-09	9.36962E-09	0.	0.	0.	0.	0.
5	0.	6.53315E-09	9.92431E-09	0.	0.	0.	0.	0.
6	0.	5.51464E-09	1.09295E-08	0.	0.	0.	0.	0.
7	0.	4.94504E-09	1.15601E-08	0.	0.	0.	0.	0.
8	0.	4.57559E-09	1.18557E-08	0.	0.	0.	0.	0.
9	0.	4.34459E-09	1.19437E-08	0.	0.	0.	0.	0.
10	0.	4.12714E-09	1.22539E-08	0.	0.	0.	0.	0.
11	0.	3.80100E-09	1.25272E-08	0.	0.	0.	0.	0.
12	0.	3.60626E-09	1.27257E-08	0.	0.	0.	0.	0.
13	0.	3.12525E-09	1.31492E-08	0.	0.	0.	0.	0.
14	0.	2.73592E-09	1.35060E-08	0.	0.	0.	0.	0.
15	0.	2.19349E-09	1.40271E-08	0.	0.	0.	0.	0.
16	0.	1.84202E-09	1.43752E-08	0.	0.	0.	0.	0.
17	0.	1.46589E-09	1.47511E-08	0.	0.	0.	0.	0.
18	0.	1.21521E-09	1.49769E-08	0.	0.	0.	0.	0.
19	0.	9.21847E-10	1.52722E-08	0.	0.	0.	0.	0.
20	0.	7.18882E-10	1.53320E-08	0.	0.	0.	0.	0.
21	0.	5.58121E-10	1.54612E-08	0.	0.	0.	0.	0.
22	0.	2.76775E-10	1.56588E-08	0.	0.	0.	0.	0.
23	0.	1.02069E-10	1.57756E-08	0.	0.	0.	0.	0.
24	0.	2.38676E-11	1.58305E-08	0.	0.	0.	0.	0.
25	0.	0.	1.59612E-08	0.	0.	0.	0.	0.
26	0.	0.	1.63070E-08	0.	0.	0.	0.	0.
27	0.	0.	2.02830E-08	0.	0.	0.	0.	0.
28	0.	0.	2.36269E-08	0.	0.	0.	0.	0.
29	0.	0.	2.66611E-08	0.	0.	0.	0.	0.
30	0.	0.	2.96116E-08	0.	0.	0.	0.	0.
31	0.	0.	3.20360E-08	0.	0.	0.	0.	0.
32	0.	0.	3.40087E-08	0.	0.	0.	0.	0.
33	0.	0.	3.53033E-08	0.	0.	0.	0.	0.
34	0.	0.	3.63716E-08	0.	0.	0.	0.	0.
35	0.	0.	3.89580E-08	0.	0.	0.	0.	6.72869E-10
36	0.	0.	3.46071E-08	0.	0.	0.	0.	5.50558E-09
37	0.	0.	3.25155E-08	0.	0.	0.	0.	1.06808E-08

	9	10	11	12	13	14	15	16
1	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.

TABLE 6-2 (CONTINUED)

6	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.

	17	18	19	20	21	22	23	24
1	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.

TABLE 6-2 (CONTINUED)

14	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.

	25	26	27	28	29	30
1	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.

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TABLE 6-2 (CONTINUED)

22	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.

DISTRIBUTIONS ON PLANE OR RING FOR GROUP 2

	FLUX			VERTICAL CURRENTS			
	TOTAL	TOP	SIDE	TOP(MAP)	TOP(DOT)	SIDE(MAP)	SIDE(DOT)
1	6.59654E-10	6.59654E-10	0.	6.58129E-10	6.15108E-10	0.	0.
2	6.60054E-10	6.60054E-10	0.	6.58518E-10	6.15480E-10	0.	0.
3	6.59138E-10	6.59138E-10	0.	6.57580E-10	6.14626E-10	0.	0.
4	6.59743E-10	6.59743E-10	0.	6.58153E-10	6.15190E-10	0.	0.
5	6.58923E-10	6.58923E-10	0.	6.57290E-10	6.14426E-10	0.	0.
6	6.58445E-10	6.58445E-10	0.	6.56759E-10	6.13980E-10	0.	0.
7	6.56991E-10	6.56991E-10	0.	6.55240E-10	6.12624E-10	0.	0.
8	6.58070E-10	6.58070E-10	0.	6.56245E-10	6.13630E-10	0.	0.
9	6.54039E-10	6.54039E-10	0.	6.52130E-10	6.09872E-10	0.	0.
10	6.56322E-10	6.56322E-10	0.	6.54317E-10	6.12001E-10	0.	0.
11	6.54241E-10	6.54241E-10	0.	6.52129E-10	6.10060E-10	0.	0.
12	6.54545E-10	6.54545E-10	0.	6.52316E-10	6.10343E-10	0.	0.
13	6.53933E-10	6.53933E-10	0.	6.51577E-10	6.09773E-10	0.	0.
14	6.51173E-10	6.51173E-10	0.	6.48681E-10	6.07199E-10	0.	0.
15	6.50481E-10	6.50481E-10	0.	6.47844E-10	6.06553E-10	0.	0.
16	6.50531E-10	6.50531E-10	0.	6.47735E-10	6.06600E-10	0.	0.
17	6.50769E-10	6.50769E-10	0.	6.47807E-10	6.06822E-10	0.	0.
18	6.49833E-10	6.49833E-10	0.	6.46691E-10	6.05949E-10	0.	0.
19	6.49301E-10	6.49301E-10	0.	6.45972E-10	6.05453E-10	0.	0.
20	6.44549E-10	6.44549E-10	0.	6.41021E-10	6.01022E-10	0.	0.
21	6.43527E-10	6.43527E-10	0.	6.39793E-10	6.00070E-10	0.	0.
22	6.40388E-10	6.40388E-10	0.	6.36447E-10	5.97142E-10	0.	0.
23	6.38304E-10	6.38304E-10	0.	6.36134E-10	5.95199E-10	0.	0.
24	6.37605E-10	6.37605E-10	0.	6.33203E-10	5.94547E-10	0.	0.

TABLE 6-2 (CONTINUED)

25	6.42118E-10	6.42118E-10	0.	6.37470E-10	5.48755E-10	0.	0.
26	6.77506E-10	6.35239E-10	4.22172E-11	6.28799E-10	5.92397E-10	4.21710E-11	-3.93574E-11
27	8.21392E-10	6.35422E-10	1.85570E-10	6.25337E-10	5.93444E-10	1.84740E-10	-1.73034E-10
28	9.63911E-10	6.15725E-10	3.43186E-10	5.99110E-10	5.74146E-10	3.44516E-10	-3.24573E-10
29	1.10534E-09	5.94451E-10	5.10938E-10	5.71523E-10	5.54317E-10	5.01975E-10	-4.75434E-10
30	1.23166E-09	5.66057E-10	6.65589E-10	5.36633E-10	5.27840E-10	6.46016E-10	-6.23641E-10
31	1.34954E-09	5.42071E-10	8.07473E-10	5.05777E-10	5.05455E-10	7.73701E-10	-7.52444E-10
32	1.45375E-09	5.19936E-10	9.33811E-10	4.76677E-10	4.84826E-10	8.81587E-10	-8.77751E-10
33	1.53389E-09	4.90773E-10	1.04311E-09	4.41469E-10	4.57631E-10	9.68561E-10	-9.72672E-10
34	1.60963E-09	4.74768E-10	1.13487E-09	4.17675E-10	4.42706E-10	1.03476E-09	-1.05823E-09
35	1.79310E-09	5.83790E-10	1.20931E-09	4.99268E-10	5.36298E-10	1.08124E-09	-1.12765E-09
36	1.83472E-09	5.67475E-10	1.26725E-09	4.73552E-10	4.62346E-10	1.10970E-09	-1.13167E-09
37	2.00489E-09	6.98300E-10	1.30659E-09	5.69230E-10	5.19452E-10	1.11951E-09	-1.21836E-09

TABLE 6-2 (CONTINUED)

FINAL RESPONSE DATA

RESPONSE DATA

POINT COORDINATES(CM) CONTRIBUTIONS FROM SURFACE AREAS

	R	Z	TOTAL	TOP OR BOT.	SIDE	TS(1, 25)	TS(1, 5)	TS(
1	1.0000	-487.5000	1.46521E-09	1.46521E-09	0.	1.46521E-09	0.	
2	3.0000	-487.5000	1.46601E-09	1.46601E-09	0.	1.46601E-09	0.	
3	5.0000	-487.5000	1.46412E-09	1.46412E-09	0.	1.46412E-09	0.	
4	7.0000	-487.5000	1.46529E-09	1.46529E-09	0.	1.46529E-09	0.	
5	9.0000	-487.5000	1.46349E-09	1.46349E-09	0.	1.46349E-09	0.	
6	11.0000	-487.5000	1.46238E-09	1.46238E-09	0.	1.46238E-09	0.	
7	13.0000	-487.5000	1.45923E-09	1.45923E-09	0.	1.45923E-09	0.	
8	15.0000	-487.5000	1.46130E-09	1.46130E-09	0.	1.46130E-09	0.	
9	17.0000	-487.5000	1.45284E-09	1.45284E-09	0.	1.45284E-09	0.	
10	19.0000	-487.5000	1.45733E-09	1.45733E-09	0.	1.45733E-09	0.	
11	21.0000	-487.5000	1.45325E-09	1.45325E-09	0.	1.45325E-09	0.	
12	23.0000	-487.5000	1.45225E-09	1.45225E-09	0.	1.45225E-09	0.	
13	25.0000	-487.5000	1.44996E-09	1.44996E-09	0.	1.44996E-09	0.	
14	27.0000	-487.5000	1.44501E-09	1.44501E-09	0.	1.44501E-09	0.	
15	29.0000	-487.5000	1.44281E-09	1.44281E-09	0.	1.44281E-09	0.	
16	31.0000	-487.5000	1.44249E-09	1.44249E-09	0.	1.44249E-09	0.	
17	33.0000	-487.5000	1.44008E-09	1.44008E-09	0.	1.44008E-09	0.	
18	35.0000	-487.5000	1.43514E-09	1.43514E-09	0.	1.43514E-09	0.	
19	37.0000	-487.5000	1.43805E-09	1.43805E-09	0.	1.43805E-09	0.	
20	39.0000	-487.5000	1.42880E-09	1.42880E-09	0.	1.42880E-09	0.	
21	41.0000	-487.5000	1.42482E-09	1.42482E-09	0.	1.42482E-09	0.	
22	43.0000	-487.5000	1.42118E-09	1.42118E-09	0.	1.42118E-09	0.	
23	45.0000	-487.5000	1.41295E-09	1.41295E-09	0.	1.41295E-09	0.	
24	47.0000	-487.5000	1.41497E-09	1.41497E-09	0.	1.41497E-09	0.	
25	49.0000	-487.5000	1.42541E-09	1.42541E-09	0.	1.42541E-09	0.	
26	62.5000	-487.5000	1.50292E-09	1.41702E-09	8.58979E-11	1.41702E-09	8.58979E-11	
27	87.5000	-487.5000	1.80463E-09	1.42697E-09	3.77662E-10	1.42697E-09	3.77662E-10	
28	112.5000	-487.5000	2.08976E-09	1.38115E-09	7.08607E-10	1.38115E-09	7.08607E-10	
29	137.5000	-487.5000	2.37227E-09	1.33245E-09	1.03983E-09	1.33245E-09	1.03983E-09	
30	162.5000	-487.5000	2.62538E-09	1.27083E-09	1.35455E-09	1.27083E-09	1.35455E-09	
31	187.5000	-487.5000	2.86462E-09	1.22132E-09	1.64330E-09	1.22132E-09	1.64330E-09	
32	212.5000	-487.5000	3.07375E-09	1.17335E-09	1.90040E-09	1.17335E-09	1.90040E-09	
33	237.5000	-487.5000	3.23045E-09	1.10763E-09	2.12283E-09	1.10763E-09	2.12283E-09	
34	262.5000	-487.5000	3.37957E-09	1.07003E-09	2.30954E-09	1.07003E-09	2.30954E-09	
35	287.5000	-487.5000	3.63185E-09	1.17083E-09	2.46102E-09	1.17083E-09	2.46102E-09	

TABLE 6-2 (CONTINUED)

36	312.5000	-487.5000	3.62279E-09	1.04388E-09	2.57891E-09	1.04388E-09	2.57891E-09
37	337.5000	-467.5000	3.81128E-09	1.15401E-09	2.65727E-09	1.15401E-09	2.65727E-09

7.0 METHOD OF SOLUTION

The numerical technique employed in the MAP code is an integration of the angular leakage flux from the visible surface of an r, z geometry model to obtain detector response at a detector surface or point. The integration over the visible source surface uses the multi-group angular flux data from a discrete ordinate transport solution in DOT-IIW* code as energy and angular dependent source data. Point kernel integration is carried out over the visible surface to provide the detector response.

Detector response at detector P in Figure 7-1 is defined by:

$$(1) \qquad D_p = \int_E K(E) \int_S \frac{q(\Omega, E, R, \theta, z)\, B(E, b) \exp(-b)}{\rho_p (r, \theta, z)^2} \, dS dE$$

where,

D_p is the detector response at detector P,

K (E) is the energy dependent detector response for detector point P

q (Ω, E, r, θ, z) is the energy-and angular-dependent source term at the source surface. This term is derived from the discrete ordinate transport angular flux data.

ρ_p (r, θ, z) is the line-of-sight distance from the source surface at coordinates (r, θ, z) to the detector point P.

B (E, b) is the buildup factor to account for multiple scatter on the line-of-sight penetration through a geometry.

b is the total mean free paths of material penetrated on the line-of-sight, ρ (r, θ, z).

E is the particle energy

The calculation of B (E, b) and b is performed at user option. If only uncollided flux is desired, then the term B (E, b) is assumed to be 1.0 for all line-of-sight calculations.

The evaluation of equation 1 is performed in MAP as a multigroup solution using numerical integration over the visible surface as follows:

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*All discussions of the DOT-IIW code are applicable to the DOT-II code with the exception that an input boundary source output tape from MAP can be used as direct input to DOT-IIW.

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$$D_p = \sum_{g=1}^{G} K_g \sum_{\substack{\text{All Source}\\ \text{Points}}} \frac{q_g(\Omega, r, \theta, z)\, B_g(b_g)\, \exp(-b_g)}{\rho_p(r,\theta,z)^2} \Delta S \qquad (2)$$

where,

G is number of groups

ΔS is surface area associated with each source point

In addition to the above evaluation, the user can obtain the multigroup angular dependent flux at the detector surface, integral detector response for portions of the visible top, bottom or side surface of the r, z geometry source surface, and the multigroup scalar flux and current at the detector surface. A discussion of each type calculation performed by the MAP code is presented in the following sections.

7.1 GEOMETRY CALCULATIONS

The MAP code performs calculations to obtain the required geometry-related data for use in the integration over the visible surface of the r, z problem geometry of the DOT-IIW code. These geometry calculations are categorized into five specific areas as follows:

- Source surface calculations to obtain a point source description of the r, z problem geometry surface,
- Detector surface calculations to represent the surface at a series of detector points,
- Source point-to-detector point geometry calculations,
- Discrete ordinate quadrature geometry data at the source point and detector point, and
- Geometry ray trace through a geometry described as zones defined by intersecting quadratic surfaces.

Each of the categories is described in detail in the following discussion with the energy dependent portion of the calculation described in Section 7.2.

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Source Surface Calculations

The source surface in the MAP code is a right circular cylindrical surface as shown in Figure 7-1. This surface is the outer boundary surface defined by an r, z geometry problem in the DOT-IIW code. The angular and energy dependent source on this surface is derived from the angular flux data calculated by DOT-IIW and these flux data are processed with the MAP code geometry data to provide detector response. In describing the surface source in the MAP code, the numerical technique involves the use of DOT angular leakage fluxes and the r, z geometry as shown in Figure 7-1 in an integration over the visible top or bottom and side surfaces. The integration is carried out independently for each detector and all geometry related data are processed prior to energy calculations in order to reduce computer time and data handling.

Subdivision of Source Surface into Finite Surface Areas

At each detector point, P, as shown in Figure 7-1, the MAP code evaluates all geometry related data for finite surface areas on the visible surface of the cylinder. The visible top or bottom surface as well as the side surfaces are calculated independently because, if the detector point lies above or below the top or bottom surface of the source cylinder, the entire disk is visible to the detector. The visible side surface is defined by the point of tangency of the line of sight connecting the detector point P and the cylindrical surface.

In addition to the geometry calculations relating source point and detector, the relationship of the discrete ray connecting the definite areas with each detector is calculated. These geometry dependent data are then associated with the discrete ordinate angular quadrature data describing the angular flux, and these data are used to process the energy dependent angular flux in subsequent calculations.

In the current version of the MAP code, two techniques exist to describe the subdivision of the visible surface area (i.e., top, bottom, or side) into finite surface areas. Each of these techniques will be discussed in the following sections.

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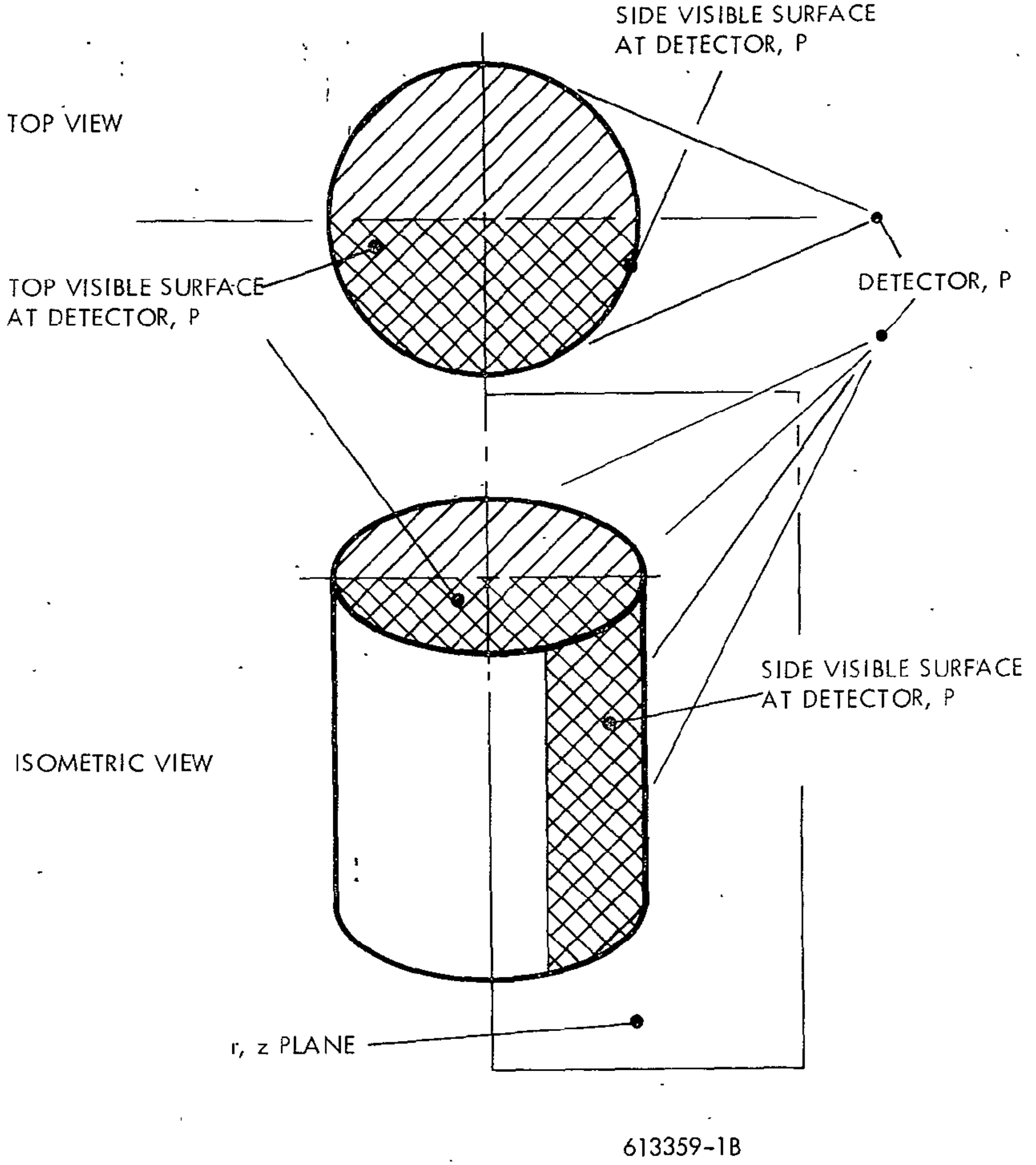

Figure 7-1. Schematic of Source Surface for MAP

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The top or bottom surface is visible to any detector above or below the plane defined by the surface and geometry calculations are similar for both surfaces. Only the top surface will be described here. The DOT - IIW angular flux available to describe the angular leakage flux from this top surface is defined only in those mesh intervals lying in the r,z plane at the top. The r,z plane is noted in Figure 7-2 and the mesh intervals, for which angular flux exists, are also noted. In the integration over the visible top surface, consistent use is made of the angular flux data at each mesh interval during the surface integration. Since the angular leakage flux is obtained only in one quadrant of the unit sphere, the MAP code performs the integration only in the range of 0 to 180 degrees,and the surface area associated with each finite surface area is doubled to account for this symmetry condition. As shown in Figure 7-2, the only input data required for the DOT-IIW code is the radial mesh line descriptions r_i , as shown schematically in Figure 2. In an r,z problem geometry, the DOT-IIW code assumes homogeneity of flux solution in the azimuthal angle θ such that the angular flux data in the r,z plane are applicable to all r, z planes with the proper translation of the coordinate system. Techniques available in MAP use an arbitrary θ mesh interval description defined by input to subdivide the top surface into a set of annular ring segments as shown in Figure 7-2. Annular ring segments are then represented as point sources (e.g., at the point S) whose cylindrical coordinates are the arithemtic mean of the surface mesh cell boundaries and the axial coordinate $\bar{z}_s$ of the surface as follows:

(3) $$\bar{r}_i = \frac{r_i + r_{i+1}}{2.0}$$

(4) $$\bar{\theta}_m = \frac{\theta_m + \theta_{m+1}}{2.0}$$

(5) $$\bar{z}_i = z_s$$

Using the symmetry condition about the r,z plane, the surface area associated with point S is given by:

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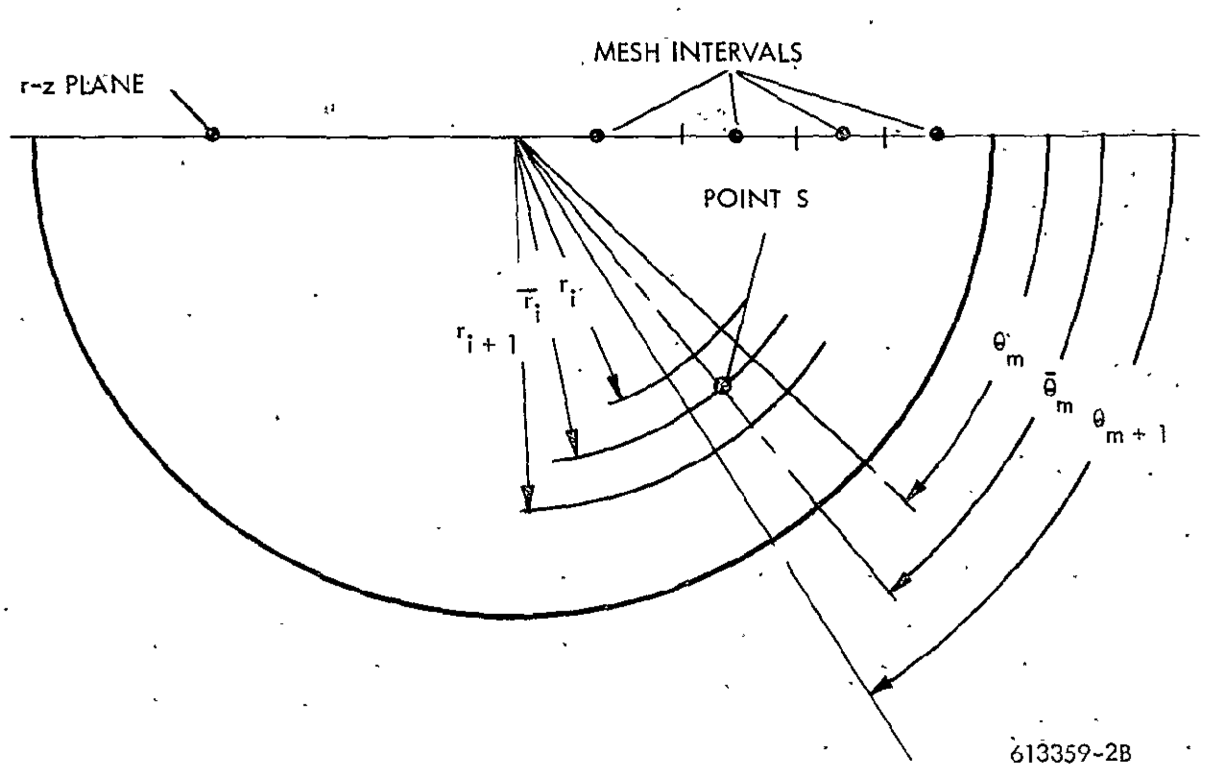

Figure 7-2. Schematic of MAP Surface Integration Technique – Top Surface

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(6) $\Delta S = (r_{i+1}^2 - r_i^2) \cdot (\theta_{m+1} - \theta_m)$

This surface area element is then used in performing the numerical integration.

The visible side surface of the cylindrical source surface is treated in a similar fashion to the top (or bottom) surface. As shown in Figure 7-3, the side surface integration involves the determination of the angle θ_T which is defined by the line of tangency of the plane containing the detector point P and the cylindrical source surface (shown by the dashed line in Figure 7-3). Once the angle θ_T is known for detector point P, the technique used to define the surface mesh cell boundaries use the arbitrary θ mesh interval description input to the MAP code to define the surface mesh cell shown in Figure 7-3. The mesh cell boundaries are from the input azimuthal angle values, θ'_m, and the DOT-IIW axial mesh line values z_i as follows:

(7) $\theta_m = \theta'_m \cdot \dfrac{\theta_T}{\theta_{m+1} - \theta_1}$

(8) $z_i = z_i$

The surface area elements defined by the mesh cell boundaries are then represented as a point source (e.g., at point S) whose cylindrical coordinates are the arithmetic mean of the surface mesh cell boundaries and the radial coordinate r_s of the cylindrical surface as follows:

(9) $\bar{r}_i = r_s$

(10) $\bar{\theta}_m = \dfrac{\theta_{m+1} + \theta_m}{2.0}$

(11) $\bar{z}_i = \dfrac{z_{i+1} + z_i}{2.0}$

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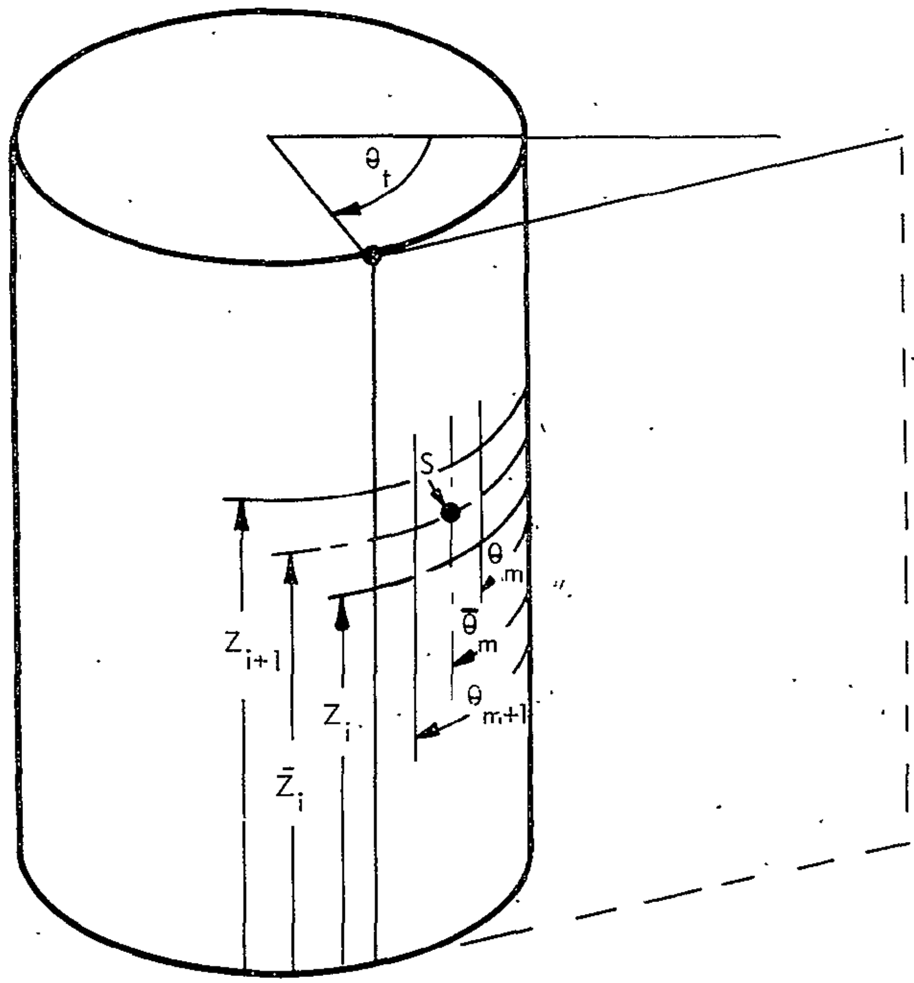

Figure 7-3. Schematic of MAP Surface Integration Technique - Side Surface

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Using the symmetry condition about the r,z plane, the surface area associated with point S is given by.

(12) $$S = 2.0 \cdot r_s \cdot (\theta_{m+1} - \theta_m) \cdot (z_{j+1} - z_j)$$

This surface area element is then used in performing the numerical integration for the side surface.

Two techniques are available in using the DOT-IIW angular flux data. The first technique uses the mesh interval description as defined by the DOT-IIW problem input directly. In this use, the angular flux data for each radial mesh interval on the top (or bottom) surface are used in combination with the MAP input azimuthal mesh interval description to define the surface source on the entire visible top (or bottom) surface.

A second technique is provided by MAP in which the user specifies the number of radial or axial mesh intervals on the top, bottom, or side surface in the surface integration. The MAP code assumes equal Δr mesh intervals in the top or bottom surface integration or equal Δz mesh intervals in the side surface integration. Angular flux data are assigned to the integration mesh intervals according to the DOT-IIW mesh interval in which the midpoint of the integration mesh interval lies. This second technique is included in the MAP code capability to provide a fine uniform mesh cell description for use with highly asymmetric quadrature angular flux data at the DOT source surface and at the MAP detector surface. The MAP code does not use any spatial interpolation techniques to define the angular flux variation at the source surface. The DOT-IIW angular flux data are used as discrete surface area data. This approach is used to circumvent smoothing of data where particle leakage from adjacent mesh cells on a surface are drastically different due to physical changes in a DOT-IIW problem geometry internal to the surface (e.g., an edge effect due to a highly absorbing shield region adjacent to a void).

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Detector Surface Calculations

Detector surfaces in the MAP code can be one of three regular surfaces or the user can, at option, input coordinates of a series of detector points. The regular detector surface definitions available to the user are:

- Plane surface detector normal to the z axis of the DOT-IIW problem,
- Cylindrical surface detector parallel to the z axis of the DOT-IIW problem, and
- Spherical surface detector (meridian ring) whose origin is defined by input data.

Each of these detector surfaces are subdivided into surface areas which are represented as point detectors. Because of the symmetry conditions in the angular leakage flux solution at the DOT-IIW surface and the use of numerical integration over the visible source surface, the three surfaces can be represented as a series of detector points on the line of intersection of the detector surface and the r,z plane of the DOT-IIW solution. The detector surfaces are shown in Figure 7-4. The techniques used in MAP to define the coordinates of the detector points defined these surface detectors are as follows:

Plane;

(13) $$\bar{r}_k = \frac{r_{k+1} + r_k}{2.0}$$

(14) $$\bar{z}_k = z_p$$

(15) $$\bar{\theta}_k = 0.0$$

Cylindrical;

(16) $$\bar{r}_k = r_p$$

(17) $$\bar{z}_k = \frac{z_{k+1} + z_k}{2.0}$$

(18) $$\bar{\theta}_k = 0.0$$

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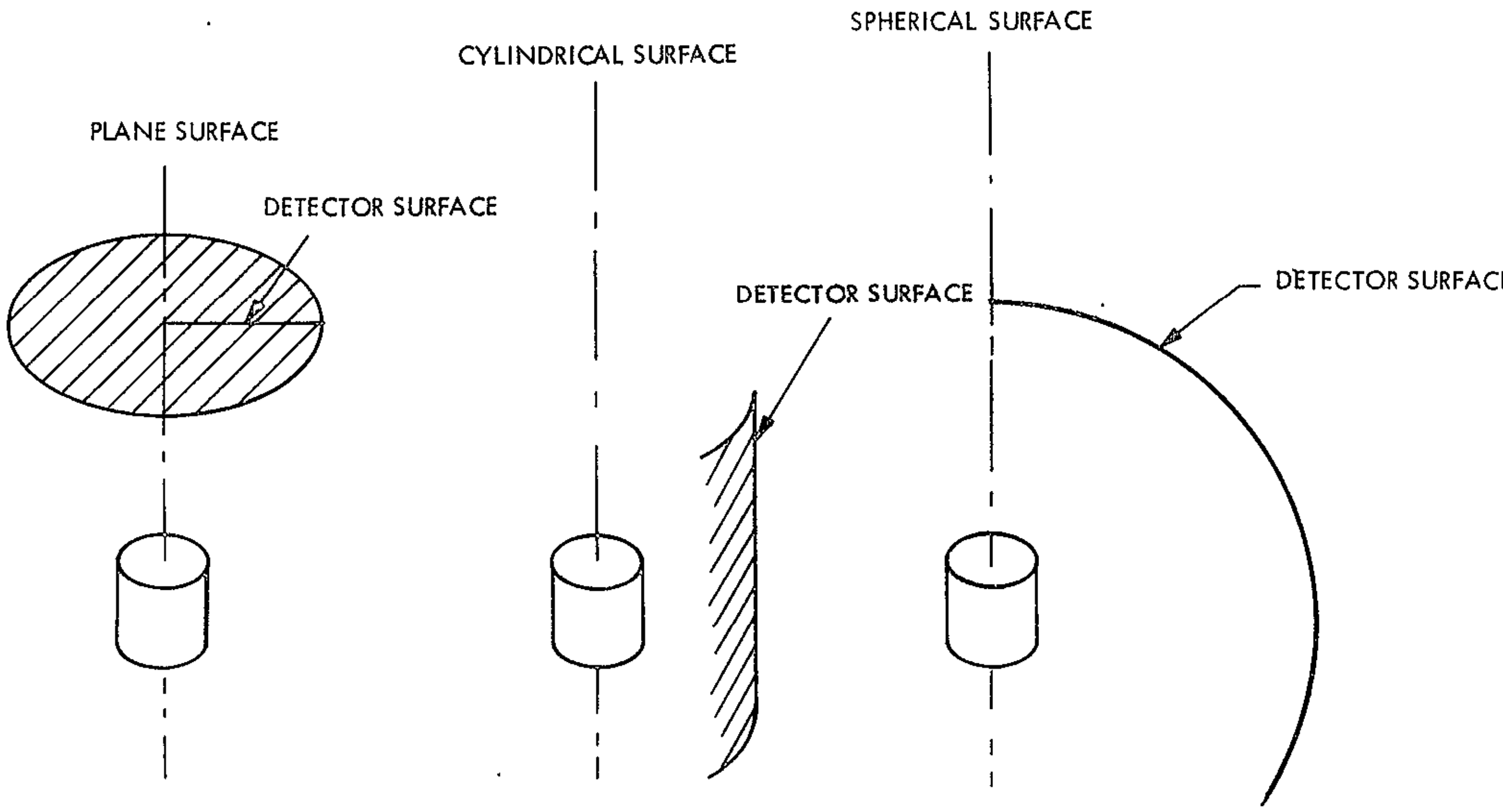

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Figure 7-4. MAP Detector Surface

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Spherical;

(19) $\bar{r}_k = r_p \cos \frac{\alpha_{k+1} + \alpha_k}{2}$

(20) $\bar{z}_k = r_p \sin \frac{\alpha_{k+1} + \alpha_k}{2} + z_p$

(21) $\bar{\theta}_k = 0.0$

Input data to the MAP consist of the radial or axial coordinates defining the mesh intervals on the detector surface, r_k or z_k, or the cosine of the polar angle, cos α_k, defining the angular mesh intervals on the spherical surface. In addition, the axial coordinates z_p of the plane, the radial coordinate r_p of the cylinder, or the origin z_p of the sphere must be input.

An additional capability available in the MAP code is the option to input the coordinates of detector points $\bar{r}_k$, $\bar{z}_k$ in order to specify a surface detector or arbitrary shape.

Source Point-to-Detector Point Calculations

The numerical integration of the kernel equation over the visible surface of the cylinder defined by the DOT-IIW solution is carried out using the point source description at the source surface described in the previous sections. Once the cylindrical coordinates of the source points and detector points are known, the void ray trace from each source point S to each detector point P is performed. These calculations are carried out as shown in Figure 7-5. An X-Y projection of the ray trace, SP, from source point S to detector P is shown. The MAP code calculates the distance, ρ_o, the angles, θ_o and θ_1, between the X-Y projection of the ray trace SP and the outward directed vectors OS or OP at points S and P. The distance, ρ_o, is obtained by the Law of Cosines as follows:

(22) $\rho_o = \bar{r}_i^2 + \bar{r}_k^2 - 2\bar{r}_i \bar{r}_k \cos\bar{\theta}_m$

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Angles θ_1 and θ_o are obtained by the following relationships:

$$(23) \quad \theta_1 = \cos^{-1} \frac{\rho_o^2 + \bar{r}_k^2 - \bar{r}_i^2}{2\,\rho_o\,\bar{r}_k}$$

$$(24) \quad \theta_o = \theta_1 + \bar{\theta}_m$$

The total ray trace distance, defined as $\rho_p(\bar{r}_i, \bar{\theta}_m, \bar{z}_i)$ from the source point S at coordinates $(\bar{r}_i, \bar{\theta}_m, \bar{z}_m)$ to detector point P at coordinates $(\bar{r}_k, \bar{z}_k)$ is then determined by:

$$(25) \quad \rho_p = \rho_o^2 + (\bar{z}_k - \bar{z}_i)^2$$

In addition to the above quantities, the MAP code computes direction cosines (μ_o, η_o) of this ray trace ρ_p at the source surface as:

$$(26) \quad \eta_o = \frac{(\bar{z}_k - \bar{z}_i)}{SP}$$

$$(27) \quad \mu_o = \cos\theta_o \cdot \sin(\cos^{-1}\eta_o)$$

The direction cosines (μ_1, η_1) of the ray trace at the detector surface are defined by:

$$(28) \quad \eta_1 = \eta_o$$

$$(29) \quad \mu_1 = \cos\theta_1 \cdot \sin(\cos^{-1}\eta_1)$$

The direction cosine sets (μ_o, η_o) and (μ_1, η_1) as well as the cosine of θ_o and θ_1 are used in subsequent calculations to obtain the angular dependent source term from discrete ordinate transport angular flux information.

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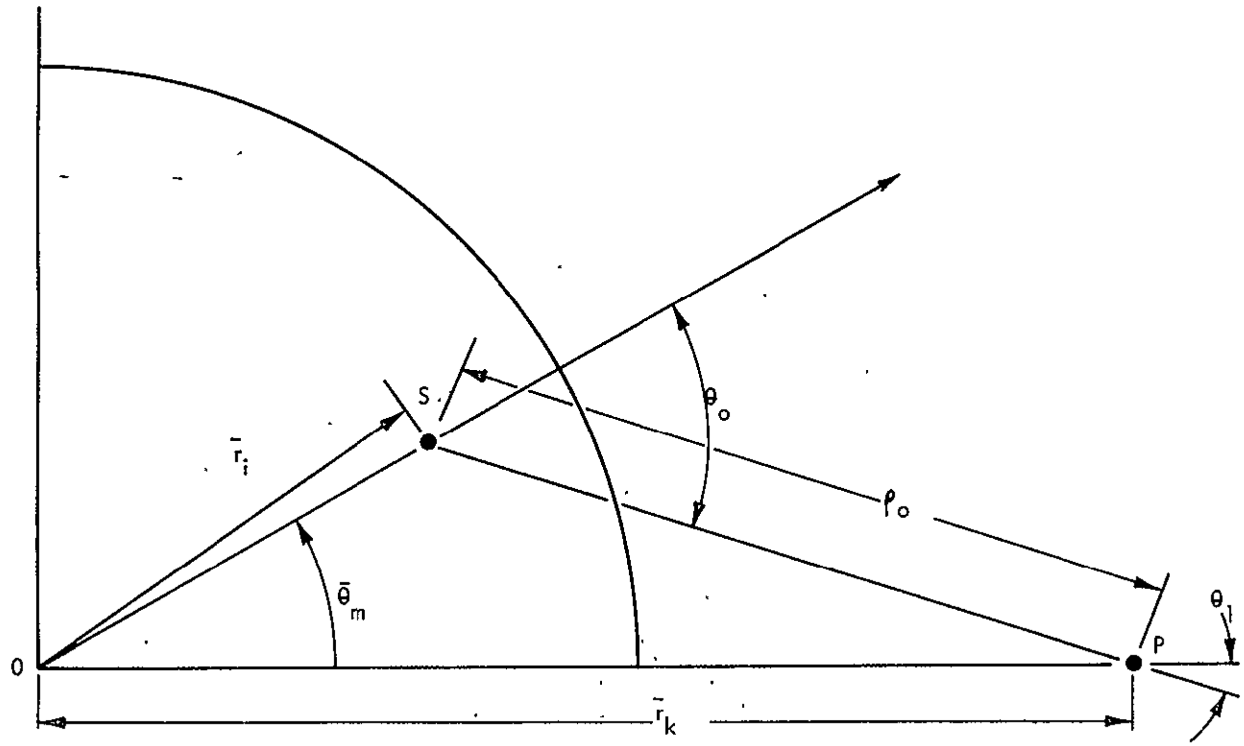

Figure 7-5. X-Y Projection of Void Ray Trace From Source to Detector Surface

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Discrete Ordinate Quadrature - Geometry Calculations

Geometry calculations associated with the discrete ordinate angular quadrature are performed for a source surface and detector surface. Calculations at the source surface are necessary to use the angular flux data at the DOT-IIW r,z problem geometry surface. Two techniques of treating this angular flux data are provided in the current version of the MAP code. These are:

- Direct use of discrete ordinate angular flux data as discrete angular source data. (This technique is used with symmetric or asymmetric quadrature data.)
- Angular flux interpolation in the angular variable, η, with the second variable, μ, treated as discrete data.

Calculations at the detector surface are associated with generating angular dependent boundary source data for direct coupling into succeeding DOT-IIW code problems using magnetic tapes. This coupling technique is applicable to any discrete ordinate quadrature and the detector surface quadrature is not required to be the same as the DOT-IIW problem data.

The following discussion will expand the preceding discussions to illustrate the generation of discrete ordinate dependent data for processing the multigroup angular flux data at the source surface.

Discrete Ordinate Quadrature - Source Surface Calculations

Discrete ordinate quadrature calculations at the source surface are carried out to provide data for calculations of angular dependent source data for use in the kernel integration over the source surface. The first technique as described above involves the direct use of angular flux data. These angular flux data are assumed to be discrete ordinate data representing the angular flux at the discrete ordinate direction cosines. A search of discrete

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ordinate directions is made to find the closest discrete direction to the line-of-sight ray connecting a source point on the surface and the detector point. This procedure is shown schematically in Figure 7-6 for the finite surface area A. Since the DOT-IIW solution is performed in the r, z plane, the translation of this plane and its related angular flux data into an azimuthal angle, $\overline{\theta}_m$, must be performed. The discrete ordinate quadrature unit sphere representing the angular flux distribution as the visible octant of the unit sphere is also shown in Figure 7-6. The MAP code performs a search of the discrete ordinate directions only in the visible octant to find the closest discrete ordinate to the ray SP connecting the source point S and detector point P. This technique involves the calculation of the direction cosines (μ_o, η_o, ξ_o) of the ray SP in relation to the $\mu = 1.0$ coordinate system shown in Figure 7-6. The discrete direction number chosen as the angular flux best representing the direction SP is chosen as the direction which forms the minimum angle ψ with ray SP as follows:

(30) $\psi = \cos^{-1} (\mu_o \mu_m + \eta_o \eta_m + \xi_o \xi_m)$.

This direction number is then saved to be used in the calculation of the angular source data described in Section 7.2.

The second technique available at the source surface involves the use of a one-variable angular flux interpolation technique in the direction cosine, η, to define the angular dependent source.[9] Geometry related data for this technique include the discrete directions, Lagrangian interpolating polynomial coefficients derived for the discrete ordinate quadrature data, and the ray SP direction cosine, η_o. The discrete directions to be used in interpolation are selected from each η_m level of the octant as shown in Figure 7-7. The selection in each η_m level is based on the cosine of the angle between the X-Y projection of the ray SP and the μ axis of the unit sphere and the angular limits of the quadrature, $\cos\theta_m$, in each η_m level. These limits are calculated based on the angular quadrature weights.

At the completion of finding the discrete direction in each η_m level of the visible octant, the mirror reflection of each discrete η_m direction is chosen based on symmetric quadratures. The η_m values of each level, η_l, and the discrete ray direction cosine η_o are then used in calculating the Lagrangian interpolating polynomial coefficients as follows:

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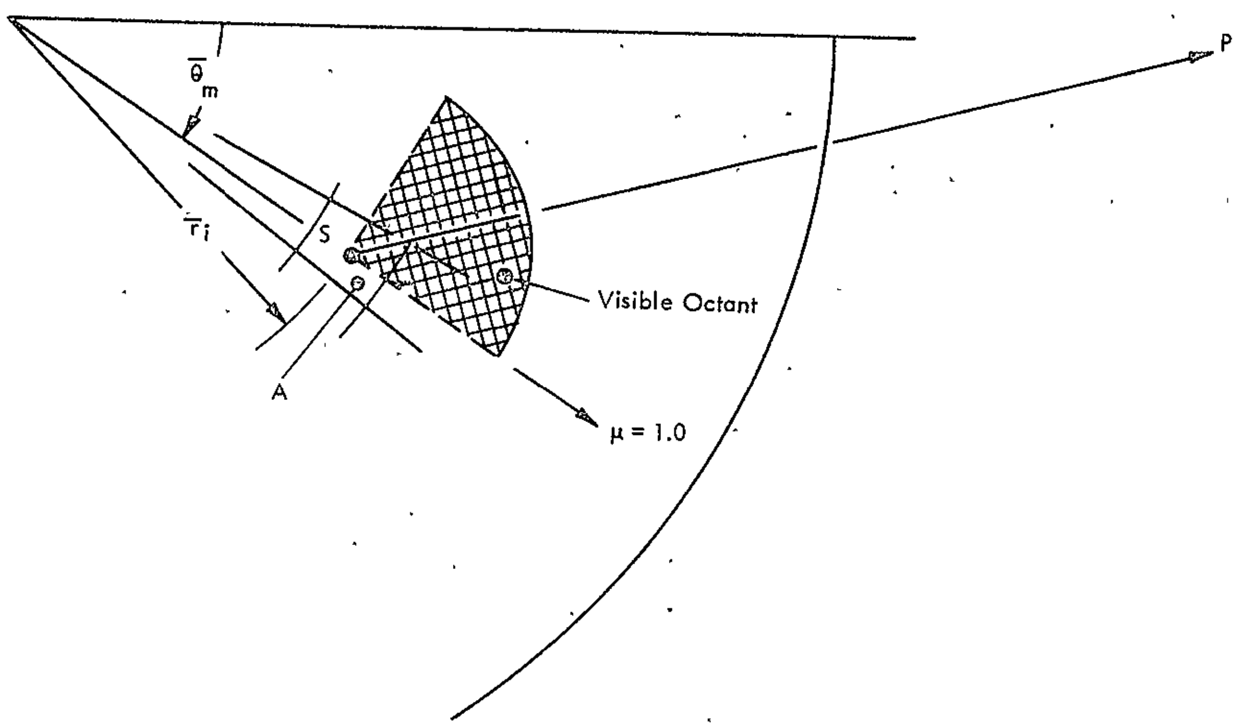

Figure 7-6. Schematic of Discrete Ordinate Unit Sphere at Source Surface

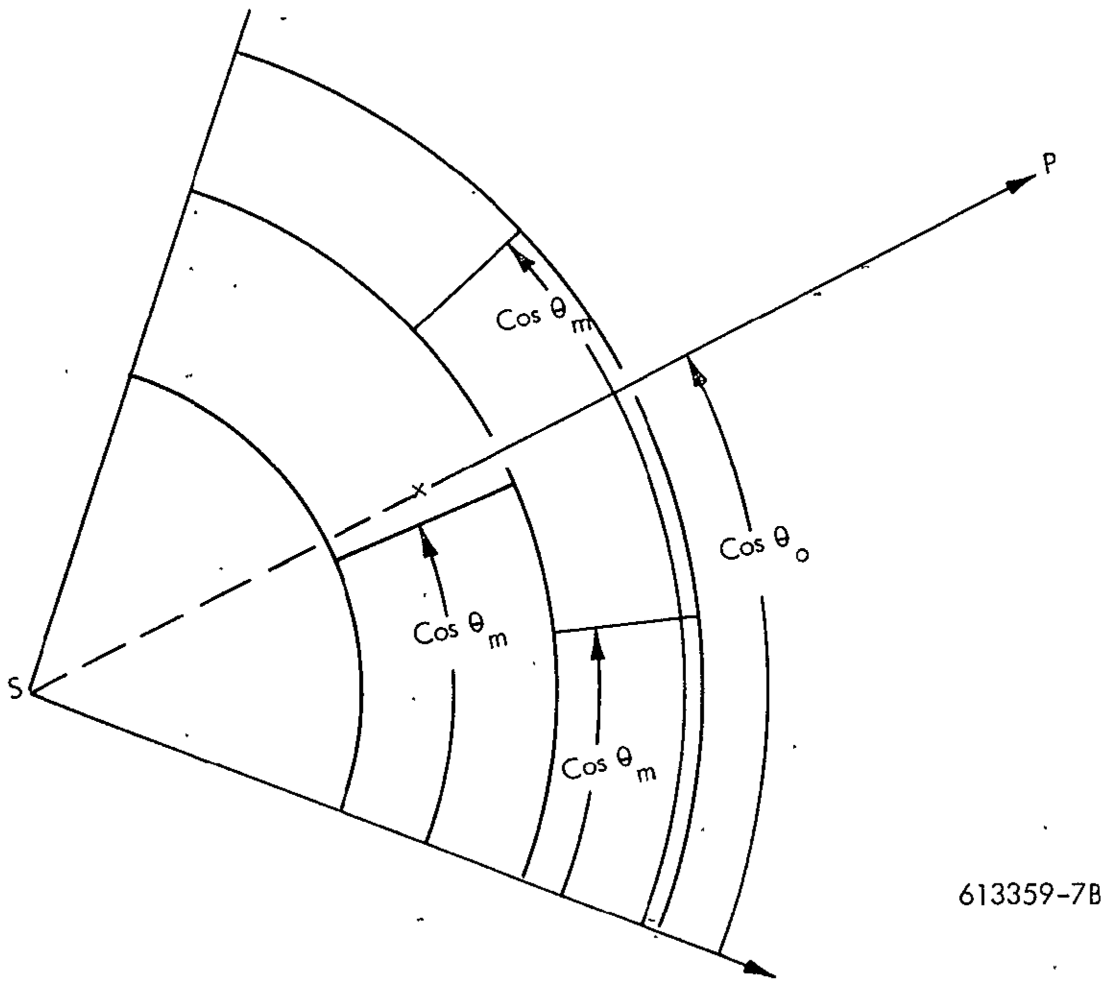

Figure 7-7. Schematic of η Level Discrete Direction Selection Procedure

$$(31) \quad L_m^n(\eta) = \frac{(1 - \eta_m^2)}{(n+1)\,[\eta_m P_n(\eta_m) - P_{\eta+1}(\eta_m)]} \cdot \frac{P_1^n(\eta)}{(\eta - \eta_m)}$$

Discussion of the angular source calculation techniques above were limited to the top source only. These techniques are directly applicable to the bottom surface except that the discrete direction search is carried out for the negative η_m quadrant of the unit sphere.

The side surface discrete direction search is carried out in the octant which is visible to the detector point, and this search will involve $+\eta$ and $-\eta$ octants depending upon the location of the detector point P in relation to the source points S. The technique described above is applicable to the side surface except that the search is limited to the $+\mu$ directions only.

GEOMETRY RAY TRACE CALCULATIONS

The MAP code, at option, will perform geometry and material penetration calculations based on a geometry defined by zones defined by intersecting quadratic surfaces. The geometric surfaces are described by various quadratic equations, and materials in the zones are described by a mixture material-component material table and component material nuclear cross sections or by macroscopic nuclear cross sections.

Based on geometry related data, the MAP code calculates the "line-of-sight" distance (path length) through each material in each zone between each source point and each detector point.

Subsequent sections describe the techniques used in describing the geometry by surfaces and zones and solving geometry dependent quantities in a MAP problem.

Surfaces

The geometry of the problem can include the following types of quadratic equation surfaces:

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- Equations of a surface of revolution about any x, y, or z coordinate axis.
- Equations of a plane normal to the x, y, or z axis of the reference system.
- Equations of an elliptic cylinder about any z axis.
- Equations of any quadratic surface by specifying appropriate equation coefficients.

To simplify the geometry input description, the program contains specific forms of the quadratic surface equations. Each of these equations is identified by an input surface equation number. The equations available are as follows:

$$A(X^2) + B(Y^2) + C(Z^2) + X_0X + Y_0Y + Z_0Z - D = 0.0$$
$$A(X-X_0)^2 + B(Y-Y_0)^2 + C(Z-Z_0)^2 - D = 0.0$$
$$(X-X_0)^2 + (Y-Y_0)^2 - D = 0.0$$
$$X - D = 0.0$$
$$Y - D = 0.0 \qquad (32)$$
$$Z - D = 0.0$$
$$A(X^2) + B(Y)^2 + C(Z^2) + X_0X + Y_0Y + Z_0Z - D^2 = 0.0$$
$$A(X-X_0)^2 + B(Y-Y_0)^2 + C(Z-Z_0)^2 - D^2 = 0.0$$
$$(X-X_0)^2 + (Y-Y_0)^2 - D^2 = 0.0$$

The quantities A, B, C, X_0, Y_0, Z_0, and D are input parameters for the surfaces in a problem. The surface equation number defines the necessary parameters and only those parameters are necessary to solve the respective surface equation. The first equation is a form of the general quadratic equation. The second equation defines an elliptic surface, which, by proper specification of the A, B, and C coefficients, can describe elliptical cylindrical surfaces with their axis parallel to each of the coordinate axes. The third equation defines a cylindric surface with its axis parallel to the Z axis. The fourth, fifth, and sixth equations define planes normal to each of the coordinates. The seventh, eighth, and ninth equations define the same quadratic surfaces as the first three equations except for the required input of the quantity D. By proper manipulation of the coefficients of a quadratic equation defining a surface, one can calculate the required coefficients A, B, C, D, X_0, Y_0, and Z_0.

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The equations shown above require that all parameters must be in units consistent with the nuclear cross sections of the zones.

Zones

A zone is defined as a region containing a homogeneous composition of materials and is bounded by a set of geometrical surfaces as defined by the quadratic surface equations. Geometrical surfaces described in a problem geometry are used to define the boundaries of zones in a problem. Each zone is described as a volume bounded by as many as six intersecting surfaces. The boundary surfaces of a zone are designated by their sequence number in input data.

The MAP code contains the "point-in-region" technique to assign the boundary surface-zone relationship values to each of the zone boundary surface numbers. This relationship of the zone with respect to each of its boundary surfaces must be known for a MAP geometry calculation. This relationship is designated by the sign (plus or minus) of the zone boundary number and is called the "ambiguity index." The ambiguity index defines the position of a zone with respect to the zone boundary surface as being an interior (+) or exterior (-) zone. In complex geometries, the assignment of ambiguity indices by the code user is difficult and time consuming. To circumvent this problem, the MAP code requires as input the Cartesian coordinates of a point (x_p, y_p, z_p) within each zone. Using these point coordinates, the designated surface numbers for each boundary of a zone, and the equation number of the surfaces, the calculation of the ambiquity index is straightforward. The surface equation and the coordinates (x_p, y_p, z_p) define the quantity, V, for each particular equation type as follows:

$$V = A(x_p - X_0)^2 + B(y_p - Y_0)^2 + C(z_p - Z_0)^2 + X_0 x_p + Y_0 y_p + Z_0 z_p - D$$

$$V = A(x_p - X_0)^2 + B(y_p - Y_0)^2 + C(z_p - Z_0)^2 - D \quad (33)$$

$$V = (x_p - X_0)^2 + (y_p - Y_0)^2 - D$$

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$$V = x_p - D$$
$$V = y_p - D$$
(33)
$$V = z_p - D$$
$$V = A(x_p - X_0)^2 + B(y_p - Y_0)^2 = C(z_p - Z_0)^2 + X_0 x_p = Y_0 y_p + Z_0 z_p - D^2$$
$$V = A(x_p - X_0)^2 + B(y_p - Y_0)^2 + C(z_p - Z_0) - D^2$$
$$V = (x_p - X_0)^2 + (y_p - Y_0)^2 - D^2$$

The sign ($\pm$) of the quantity V determines the ambiguity index of the boundary surface of the zone. This ambiguity index is assigned to the surface boundary number by the MAP code. If V is negative, the zone is internal to the boundary surface and the surface boundary number is given a positive sign. Similarly, if V is positive, the zone is external to the boundary surface and the surface boundary number is given a negative sign. The ambiguity index calculation is performed at the beginning of a MAP code calculation and the computed signs are used for all geometry calculations.

External zones in a MAP code problem can be described by a single boundary surface. External boundary surfaces of external zones need not be defined. An external zone is recognized by the program if the sign of the input value of the number of boundary surfaces of a zone is a negative number.

Geometry Calculations

The geometry calculation begins with the computed Cartesian coordinates of a source point (x_S, y_S, z_S) and a detector point (x_p, y_p, z_p). These coordinates are computed as follows:

Source Point

$$x_S = \overline{r}_k \cos \overline{\theta}_m \text{ or } rp\cos \overline{\theta}_m$$

$$y_S = \overline{r}_k \sin \theta_m \text{ or } rp\sin \overline{\theta}_m$$

$$z_S = \overline{z}_k$$

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Detector Point

$x_P = \bar{r}_i$

$y_P = 0.0$

$z_P = \bar{z}_i$

The total "line-of-sight" distance, ρ, between a source point and a detector point, and the direction cosines (α, β, γ) are then computed as follows:

$$\rho = (x_P - x_S)^2 + (y_P - y_S)^2 + (z_P - z_S)^2$$

$$\alpha = \frac{x_P - x_S}{\rho}$$

$$\beta = \frac{y_P - y_S}{\rho}$$

$$\gamma = \frac{z_P - z_S}{\rho}$$

The geometry calculation then proceeds to obtain the path length, ρ_Z, traversed in each zone along the "line-of-sight." This calculation begins with the coordinates of a "pseudo-point" (x', y', z'), along the "line-of-sight" which is removed from the original source point by the distance Δ. This calculation is performed as:

$x' = x_S + \alpha\Delta$

$y' = y_S + \beta\Delta$

$z' = z_S + \gamma\Delta$

This pseudo-point (x', y', z') is used in conjunction with input zone boundaries, surface numbers, surface equations input surface parameters, and the source zone number to calculate the correct zone in which x', y', and z' lies. The actual operation performed is a cyclic calculation of the quantities, V_{bZ}, for each boundary, b, of the source zone, Z. The cyclic calculation begins in the zone area. The values of V_{bZ} depend on the equation number $NEQBD_b$ of boundary b and follow as:

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$$V_{bz} = A\,(x' - x_0)^2 + B\,(y' - y_0)^2 + C\,(z' - z_0)^2 + x_0x' + y_0y + z_0z' - D$$

$$V_{bz} = A\,(x' - x_0)^2 + B\,(y' - y_0)^2 + C\,(z' - z_0)^2 - D$$

$$V_{bz} = (x' - x_0)^2 - (y' - y_0)^2 - D$$

$$V_{bz} = x' - D$$

$$V_{bz} = y' - D$$

$$V_{bz} = z' - D$$

$$V_{bz} = A\,(x' - x_0)^2 + B\,(y' - y_0)^2 + C\,(z' - z_0)^2 + x_0x' + y_0y' + z_0z'$$

$$V_{bz} = A\,(x' - x_0)^2 + B\,(y' - y_0)^2 + C\,(z' - z_0)^2 - D^2$$

$$V_{bz} = (x' - x_0)^2 + (y' - y_0)^2 - D^2$$

If the sign of the quantity, V_{bz}, and the sign (ambiguity index) of the boundary surface number are of opposite sign for all boundary surfaces, the point (x', y', z') lies within the region or zone. If the point does not lie in the zone, the code searches the zones in sequence up to the number of zones in the problem. If a zone is found which contains the point (x', y', z'), the calculation proceeds to the next geometry calculation step. If no zone can be found which contains the point, the region calculation is terminated by printing an error statement along with the results for source regions preceding that one in which the error occurred.

The next step in calculating the path length in each region involves the analytic solution of distances from the point (x', y', z') to each boundary surface of the zone. The solution is obtained by solving the boundary equations for the point of intersection of the "line-of-sight" and the surface in question. These distances to each boundary are sequentially tested, and the minimum distance in the correct direction is selected as the distance ρ_z from the "pseudo-point" (x', y', z') to the correct boundary.

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At this point in the calculation, the correct path length in the zone is calculated as:

$$\rho_Z = \rho'_Z + \Delta$$

The final operation in the source zone path length calculation is the starting point for obtaining the next zone (along the line-of-sight) path length. Input values define the "most probable" zone entered upon crossing boundary b of the zone z. With the last calculated value of ρ_Z, a new "pseudo-point" along the line-of-sight is calculated as:

$$x' = x' + \alpha \rho z$$

$$y' = y' + \beta \rho z$$

$$z' = z' + \gamma \rho z$$

These current "pseudo-point" coordinates and the zone number are used in the operations described above in calculating data for the next zone traversed in the source-detector "line-of-sight." The data of the correct zone number and zone path length are obtained for each zone along the line-of-sight. This cyclic procedure (calculation of zone path length) contimues until an "outside zone" is reached or until the detector point (xp, yp, zp) is reached. This source point-to-detector point calculation is repeated foreach source point on the source surface and each detector point in the problem. The total mean free paths of material on each line-of-sight for each group is calculated using neutron or photon cross sections described in Section 7.2.

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7.2 ENERGY DEPENDENT CALCULATIONS

The MAP code performs energy dependent calculations at three points in the code logic.

These three separate calculations are:

- Optional calculation of material penetration for each group using input neutron or photon cross sections or calculated photon cross sections at the energy points describing the average energies of the groups
- Calculation of the multigroup angular dependent detector response, and
- Calculation of the detector response.

Each of the three categories of calculations is described in the following discussion.

Material Penetration Calculation

In Section 7.1 the techniques of calculating the geometry ray trace were described. The calculated zone path lengths, ρ_z, on each ray trace from a source point to a detector point are combined with the multigroup macroscopic neutron or photon cross sections to provide the total mean free paths of material penetration on each ray trace.

Two techniques of specifying neutron and photon cross sections are provided in the MAP code. The user may input multigroup cross sections for a number of materials and assign materials to zones or an optional calculation of the photon cross sections by material can be performed by the code using microscopic library data on magnetic tape.

The calculation of the material penetration on each ray trace, b_g, is defined by:

$$b_g = \sum_{z=1}^{Z} \Sigma_{gz} \rho_z$$

where the cross sections, Σ_{gz}, are macroscopic total cross section data for the zone. The material penetration results are calculated for each source point and group and stored on magnetic tape or disk file by detector point for subsequent use in the calculation of the multigroup flux data described in later sections.

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The optional calculation of the photon cross sections involves the use of a mixture material - component material talbe to specify the density (grams per cubic centimeter) of elements in each mixture material. These data are combined with photon cross sections calculated from a microscopic library tape to form macroscopic cross sections.

Component materials, which may be used in as many mixture materials as desired, are defined in a matrix of input values A_{mc}. The values, A_{mc}, define the density (grams per cubic centimeter) of each component c in mixture m and are used to calculate the photon cross sections as follows:

$$\Sigma gm = \sum_{c} \sigma_c (E_g) A_{mc}$$

A "void" is defined as a mixture material in which all component materials are with zero density.

The technique of calculating the microscopic cross sections, $\sigma_c (E_g)$, involves the use of a basic library of energy dependent photo-electric and pair-production data. An internal calculation of the absorption cross section and Compton scattering cross section from the Klein-Nishina equation provides photon cross section data for use in geometry ray trace calculations.

<u>Basic Library Data</u>

The basic library tape required for the MAP code is in the format generated by the GAMLEG-W code.

The basic data were obtained from Reference 7. These data were compiled in tabular form for the 51 elements shown in Table 7-1 as pointwise data at energy points in the range of 0.01 MeV to 20.0 MeV. Only pair-production and photon-electric data were required as the Compton data are obtained analytically. The number of energy points for each element data was dependent on the number of points required to accurately describe the variations of the data with energy. For photo-electric absorption, the

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presence of a double valued function at the K, L, and M electron shell absorption edges necessitated the use of continuous data by use of values of the cross section at two energy points, $E_g + \delta$ and $E_g - \delta$, where δ was on the order of 0.001 MeV. This treatment allowed the use of these data in the interpolation techniques to obtain specific energy point values in each code as well as the accurate representation of the double valued electron shell edges.

A description of the contents of the pair-production and photo-electric cross section library tape is shown in Table 7-2. As indicated, each element requires that the data be in order of increasing photon energy. Five binary records describe each element on the magnetic tape. This magnetic tape contains a title record as the first record on tape.

The techniques employed in the MAP code involve the use of the magnetic tape library data as input to a separate subroutine. This subroutine calculates the absorption cross section, $\sigma_a(E_i)$, from the sum of the photo-electric absorption cross section, $\sigma_{pe}(E_i)$, and pair production cross sections, $\sigma_{pp}(E_i)$. This data is then interpolated to specified energy point values, E_g, to provide the total absorption cross sections, $\sigma_a(E_g)$. The interpolation technique used in the code assumes a linear variation of the logarithm of the cross section values with the logarithm of the energy for the two energy points bounding the input specified energy value, E_g. If the energy point E_g, outside the range of the pointwise data an error message is returned and if a value of the pointwise data is zero the interpolant is set to zero.

The calculation of the total cross section in the MAP code provides total cross section data at input specified energy points only. The interpolated absorption data, $\sigma_a(E_g)$, described earlier is combined with the Compton scatter cross section, $\sigma_c(E_g)$, to provide the total cross section $\sigma_t(E_g)$. The Compton cross section in units of barns/electron is calculated from the Klein-Nishina equation for the inelastic scattering of a photon of energy, E_g, with a free electron as follows:

$$\sigma_c(E_g) = \left(\frac{3}{8}\right)(0.665)\frac{\ln(1+2E_g)\left[E_K - 2 - \frac{2}{E_g}\right] + 4 + \frac{2E_K^2(1+E_g)}{(1+2E_g)^2}}{E_g^2}$$

, E_g is in units of electron rest masses.

TABLE 7-1

GAMMA RAY CROSS SECTION LIBRARY DATA PLACED ON TAPE BY GAMLEG-W

Library Identification Number	Atomic Number	Element Name	Library Identification Number	Atomic Number	Name Element
1	1	Hydrogen	26	39	Yttrium
2	2	Helium	27	40	Zirconium
3	3	Lithium	28	41	Niobium
4	4	Beryllium	29	42	Molybdenum
5	5	Boron	30	47	Silver
6	6	Carbon	31	48	Cadmium
7	7	Nitrogen	32	49	Indium
8	8	Oxygen	33	50	Tin
9	11	Sodium	34	55	Cesium
10	12	Magnesium	35	56	Barium
11	13	Aluminum	36	62	Samarium
12	14	Silicon	37	64	Gadolinium
13	15	Phosphorus	38	66	Dysprosium
14	16	Sulfur	39	70	Ytterbium
15	19	Potassium	40	72	Hafnium
16	20	Calcium	41	73	Tantalum
17	22	Titanium	42	74	Tungsten
18	23	Vanadium	43	79	Gold
19	24	Chronium	44	80	Mercury
20	25	Manganese	45	82	Lead
21	26	Iron	46	84	Polonium
22	27	Cobalt	47	90	Thorium
23	28	Nickel	48	91	Protactinium
24	29	Copper	49	92	Uranium
25	30	Zinc	50	93	Neptunium
			51	94	Plutonium

TABLE 7-2

REQUIRED BASIC LIBRARY DATA FORMAT
(Repeated for Each Element)

Punch Card Type and FORTRAN Form	Magnetic Tape**	Required Data
1. (2X, 12A4)	Record 1	Name of Element
2. (13,2E12.5)	Record 2	IA, number of energy points Z, Atomic Number of element, electrons/atom AW, Atomic Weight of element atoms/gram-atom
3. (6E12.5)	Record 3	E_i,* IA point values of energy describing the cross section input, MeV
4. (6E12.5)	Record 4	$\sigma_{pe}(E_i)$, IA values of photo-electric absorption cross sections at energy points, (E_i), barns
5. (6E12.5)	Record 5	$\sigma_{pp}(E_i)$, IA values of pair-production cross sections at energy points, (E_i), barns

* Values of E_i must be in increasing order.

** The lead record on the tape contains a title record. The library tape contains (5 x 51) + 1 records.

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The total cross section, $\sigma_t(E_g)$, in barns, is then defined as,

$$\sigma_t(E_g) = \sigma_a(E_g) + Z_i \bullet \sigma_c(E_g)$$

where Z_i is the atomic number (electrons/atom) of the element. In the MAP code, these data are combined with densities for each material to form macroscopic cross section data in units of cm^{-1}.

Multigroup Angular Dependent Calculations

In Section 7.1 the techniques of calculating geometry dependent data for the source surface and detector surface are described. These geometry related data are processed with the multigroup angular leakage flux to provide the desired detector response. The calculations performed in the energy dependent portion of the MAP code include the evaluation of the multigroup angular dependent source, the inverse square attenuation, the material attenuation, and the detector response by energy group, source surface area, and angle.

The angular dependent source by energy group for the top or bottom surface is defined as;

$$q(\Omega, r, z) = |\eta_o| \quad \phi(\eta_o, \mu_o)$$

or for the side surface as;

$$q(\Omega, r, z) = |\mu_o| \quad \phi(\eta_o, \mu_o)$$

where the direction cosines μ_o and η_o are at the source surface and are defined in Section 7.1.

Two techniques of selecting discrete direction angular flux are described in Section 7.1. The first technique involves the use of the closest discrete ordinate direction for the values of $\phi(\eta_o, \mu_o)$ and requires only the ordinate direction number to evaluate $\phi(\eta_o, \mu_o)$. The second technique involves the evaluation of an interpolating polynomial as follows;

$$\phi(\eta_o, \mu_o) = \sum_{l=1}^{n} L_m^n(\eta_o) \quad \phi(\mu_m, \eta_m)$$

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where the technique of selecting discrete direction angular flux $\phi(\mu_m, \eta_m)$ and the calculation of the polynomial coefficients $L_m^n(\eta_o)$ are described in Section 7.1.

The inverse square attenuation applied to the angular dependent source is the inverse of the square of the distance ρ_p from the source point to the detector point. The calculation of this distance is described in Section 7.1.

The material attenuation term is calculated based on the total mean free paths of material traversed along the line-of-sight. The calculation of the mean free paths is described earlier. The differential detector response by energy group, $\Delta\phi_d(\Omega)$, due to a single source point is then defined as:

$$\Delta\phi_d(\Omega) = \frac{q_g(\Omega, r, \theta, z) B(b_g) \exp(-b_g) \Delta S}{\rho_p(r, \theta, z)^2}$$

The material attenuation factor, $B(b_g) \exp(-b_g)$, is an optional calculation. The buildup factor $B(b_g)$ to account for multiple scattering of photons during the point kernel calculation is defined by the cubic polynomial,

$$B(b_g) = a_o + a_1 b_g + a_2 b_g^2 + a_3 b_g^3$$

where the coefficients a_o, a_1, a_2, a_3, are energy dependent coefficients obtained from analysis of infinite-medium moments method results[8].

Multigroup Detector Response

Detector response by energy group is calculated for the top or bottom, side, total, and selected portions of the visible source surface. The detector response, ϕ_g^s for surface area S, is obtained by summation of the differential detector response, $\phi_{gni}(\Omega)$, as follows:

$$\phi_g^s = \sum_{i \text{ or } j} \sum_n \Delta\phi_{gni}(\Omega)$$

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where the summation over i or j is over either the top or bottom surface (i), the side surface (j), the total surface (i and j), or, at option, over selected portions of i and j defined by input to the MAP code. The summation over n is the integration over the azimuthal angle, θ, on the visible surface.

In addition to the scalar detector response, a multigroup angular flux representing a boundary source at a plane normal to the z axis or r axis is calculated. This calculation involves use of the discrete direction in the coupling plane discrete ordinate quadrature which best represents the direction, Ω. The angular flux at the coupling plane normal to the z axis is defined as:

$$\phi_g (\mu_m, \eta_m) = \sum_{i \text{ and } j} \sum_{n} \frac{\eta_o}{\eta_m} \frac{\Delta\phi_{gni} (\Omega)}{w_m}$$

where the index, m, is the representative discrete direction with direction cosines, μ_m and η_m. The term, $\frac{\eta_o}{\eta_m}$, preserves the number of particles incident upon the coupling plane. The angular flux at the cylindrical coupling plane normal to the r axis is defined as:

$$\phi_g (\mu_m, \eta_m) = \sum_{i \text{ and } j} \sum_{n} \frac{\mu_o}{\mu_m} \frac{\Delta\phi_{gni} (\Omega)}{w_m}$$

These angular dependent data are placed, at user option, on magnetic tape in a format compatible with the DOT-IIW code.

Detector Response

Detector response calculations in the MAP code are carried out at the completion of the source surface integration for all energy groups and detector points. The multigroup detector fluxes for the total, top or bottom, and side surfaces as well as selected portions (i.e., tagged surface areas) of the top or bottom, and side surfaces are multiplied

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by the multigroup detector response data, K(E) or Kg, to provide detector response. The user may input detector response data for as many types of detectors desired and the MAP code will calculate the detector response for each type of detector at each detector point. The detector point data for the source surfaces (i.e., top or bottom, side, total, or tagged surface areas) are included in the detector response calculations.

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8.0 REFERENCES

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