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Contract No. NAS-8-24919
Control No. DCN 1 - X - 80 - 00056

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

VOLUME 6

POINT KERNEL TECHNIQUES

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FOREWORD

This report is Volume 6 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 the KAP-VI and SCAP 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 KAP VI computer code for solving energy dependent radiation transport external to a radiation source is described. KAP VI is a revised version of the KAP V code and is written in standard USASI FORTRAN IV. Revisions include the data input interface with the GAMLEG-W and NAGS code, as well as options to preferentially exclude multiple scatter buildup approximations in certain zones. The KAP VI (Point Kernel Attenuation Program) code employs the point kernel method to calculate neutron and gamma ray radiation levels at detector points located within or outside a complex geometry (including the radiation source) describable by a combination of quadratic surfaces. The code can be used, for example, to calculate gamma ray and/or fast neutron flux, dose, or heating rate. The attenuation function, or kernel, for gamma rays employs exponential attenuation along with a buildup factor to account for multiple scales. Three optional fast neutron attenuation functions are included: (1) a modified Albert- Welton function for calculating fast neutron dose rate using removal cross sections; (2) a bivariant polynomial expression for computing neutron spectra using infinite media moment data; and (3) a monovariant polynomial expression for computing neutron spectra using infinite media moments data. The code also handles either cylindrical, spherical, disc, line, or point sources. A variety of options are available for describing neutron or gamma ray source distributions in complex geometries.

The SCAP computer code for solving energy dependent radiation transport in a complex scattering geometry is described. The SCAP (SCatter Analysis Program) code employs the point kernel method to calculate the gamma ray or neutron radiation levels of a detector point located within or outside a complex scattering geometry describable by a combination of quadratic surfaces. The code employs an anisotropic point source represented as energy and angular dependent input values, single or albedo - scatter methods, and exponential material attenuation to calculate dose rates and gamma ray energy deposition at a detector point.

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1.0 INTRODUCTION

This report is Volume 6 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 KAP VI and SCAP codes using the point kernel technique.

The KAP VI and SCAP 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 contract (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 neutron fluxes, neutron and photon energy sources and distributions 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 energy deposition 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

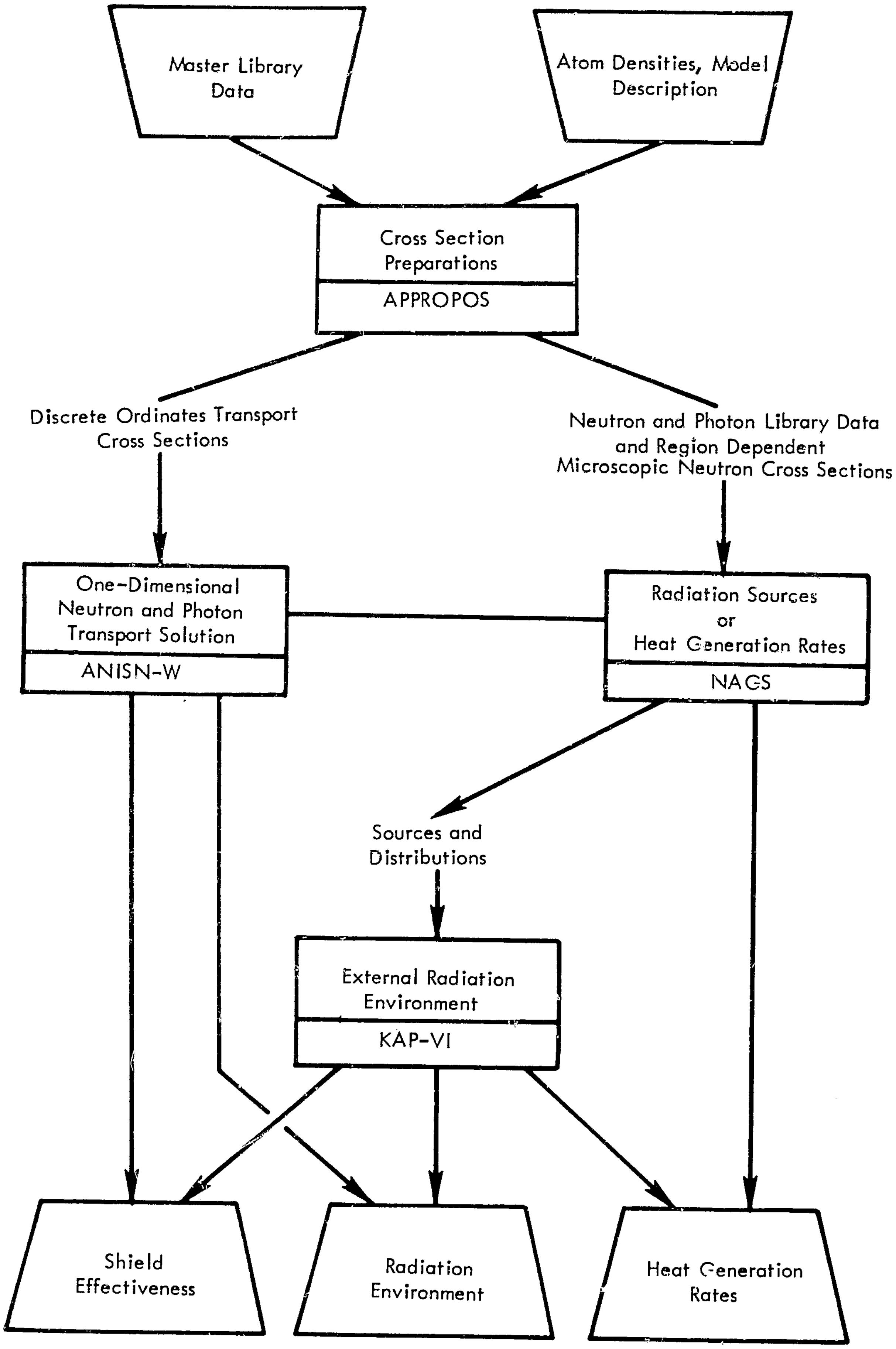

Figure 1-1. Flow Chart for Preliminary or Parametric Radiation Analysis

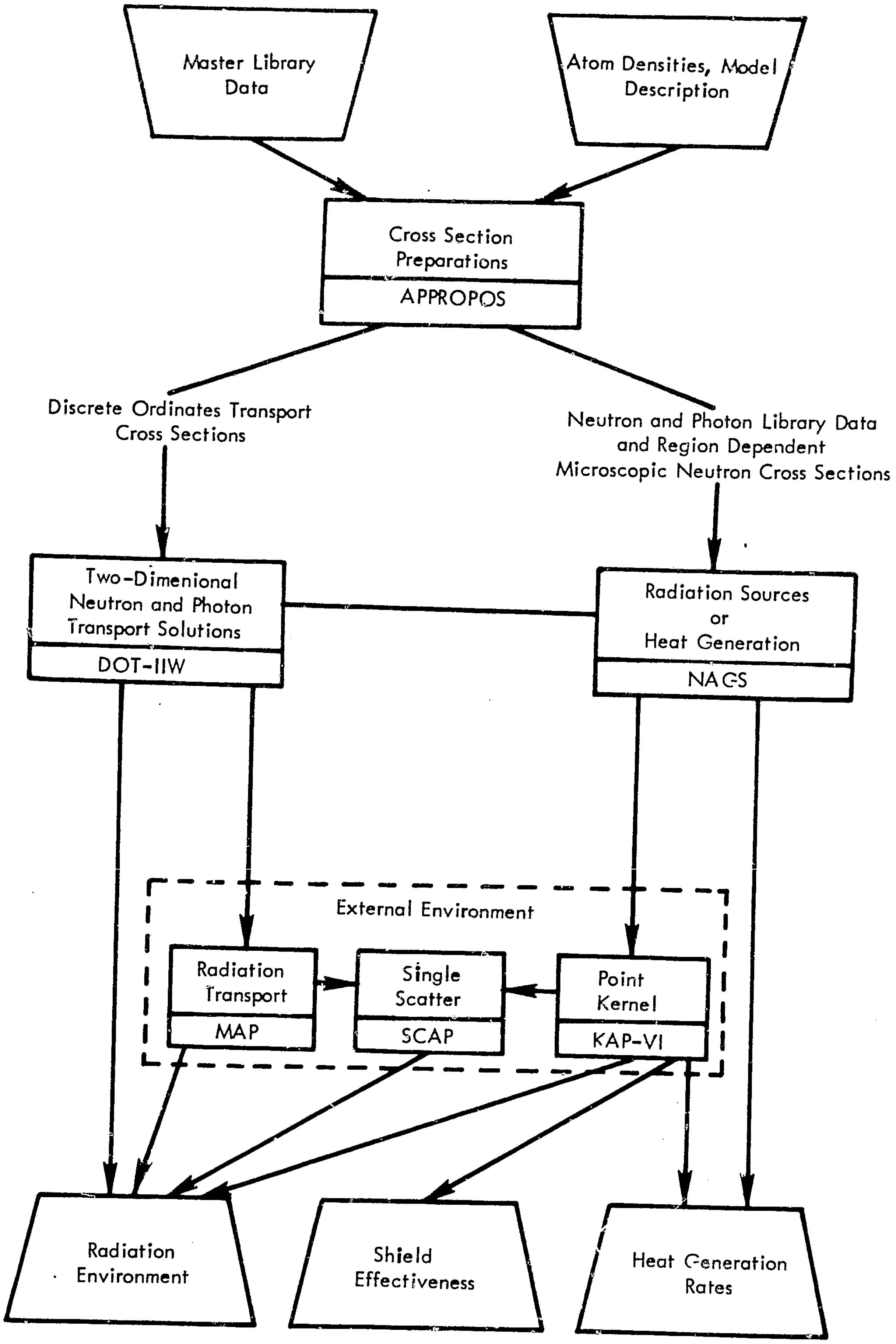

Figure 1-2. Flow Chart for Detailed Radiation Analysis

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-scatter or albedo 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, point kernel technique codes serve as the basis for many different types of calculations such as parametric analyses of nuclear rocket or space power shield designs, space nuclear propulsion system configurations, propellant management studies, and radiation environment and effects studies. The combination of the KAP VI point kernel code and the SCAP single-scatter or albedo code provides flexible yet efficient point kernel method which uses consistent geometry and cross section data. Punched data and output for the KAP VI code are used as input to the SCAP code.

The KAP VI code is a revision of the KAP V code to update its capability to automate the data interfaces with NAGS, GAMLEG-W, and SCAP codes. The present version of the KAP VI code is operational on the UNIVAC 1108 computer under the EXEC 8 Monitor System.

The SCAP code is a single-scatter or albedo code which duplicates the geometry capability of the KAP VI code and employs a consistent set of gamma ray cross section and binary factor data. The single scatter technique uses scatter point densities based on a spherical coordinate system integrated about anistropic point source. Input source data are from the KAP VI or MAP codes.

The code is in standard USASI FORTRAN language. The present version is operational on the MSFC UNIVAC 1108 computer under the EXEC 8 Monitor System.

2.0 KAP VI CODE

KAP VI is a point kernel code designed to calculate the radiation level at detector points located within or outside a complex radiation source geometry describable by a combination of quadratic sufaces. The code evaluates the material thicknesses intercepted along the line-of-sight from the source point to the detector point. These material thicknesses (or path lengths) then are employed in attenuation functions to calculate the flux, dose rate, or heating rate at the detector. The attenuation function for gamma rays employs exponential attenuation with a buildup factor. Three optional neutron attenuation functions are included: (1) a modified Albert-Welton function for calculating fast neutron dose rate using removal cross sections; (2) a bivariant polynomial expression for computing neutron spectra using infinite media moments data; and (3) a monovariant polynomial for computing neutron spectra using infinite media moments data.

The code also handles either cylindrical, spherical, disc, line, or point sources. Different source distributions may be employed for neutrons and gamma rays. A variety of options is available for describing the source distributions. The source distributions are assumed separable along the axis and radius of cylindrical- type source regions and independent of the azimuthal angular position for either spherical or cylindrical sources. An option is provided to describe azimuthal source density variation by specifying input data for discrete point sources.

Specific desirable features which have been incorporated in the KAP VI code are:

(1) Input data preparation has been simplified to allow minimum input for running "stacked" cases.

(2) The code uses the "point-in-region" concept to calculate the boundary surface-zone relationship ("ambiguity index") which is required as input in other point kernel codes.

(3) A routine is included in the code to calculate gamma ray mass absorption coefficients for up to twenty elements as a function of input gamma ray energy from either internal calculations or from magnetic tape data and internal calculations.

(4) A routine is included in the program to calculate the cubic polynomial coefficients for buildup factors as a function of input gamma ray energy from a library of bivariant polynomial data.

(5) A routine is included which will interpolate a closely-spaced source distribution (obtained from a discrete ordinate transport source calculation) to a source mesh description more economic and amendable to point kernel calculations.

(6) A routine is included which calculates and normalizes point source strengths for a variety of source geometries and functional variations of source distributions.

(7) Input data are checked for consistency to eliminate many erroneous calculations that can occur if input data for a problem are incomplete.

(8) The program has the capability to calculate fluxes and/or other radiation responses such as heating rates at multiple detector points for each source region.

(9) The program has no set limit on the number of source regions which can be run in a single problem. This feature is handled as a set of stacked source region problems. The program computes the summation at each detector point of the neutron and/or photon radiation from each source region.

(10) The program allows the user to input separate source distributions for neutrons and gamma rays within the same source region.

(11) The program eliminates unnecessary response function computations by accumulating flux data as a function of detector point and group during the calculation for each source region. Calculations for up to ten response functions are performed only at the completion of each source region calculation and/or at the completion of source region problems.

(12) An option is included for calculating the flux at a detector located within a gamma ray source region. This option circumvents the numerical difficulties introduced by the "inverse square law" when a source point is too close to the detector.

(13) An option is included to accept NAGS punched card data as input source data.

(14) An option is included to provide punched card output for use in the SCAP code.

Section 2.2 gives a description of the required input data for the KAP VI code. Section 2.3 gives a detailed input data information for specific data arrays. Section 2.4 briefly describes problem setup information, including tape assignments, running time and a sample problem. Section 2.5 gives a description of the KAP VI output data. Section 2.6 describes the code logic and Section 2.7 provides a description of the numerical method of solving the point kernel problem.

2.1 COMPUTER CODE SYNOPSIS

1. Name: KAP-VI
2. Computer: The code is operational on the MSFC UNIVAC 1108 computer system under EXEC8 monitor system control.
3. Nature of Physical Problem Solved:

   KAP VI solves for radiation transport in complex geometries using the point kernel method. The code is designed to calculate the neutron and gamma ray radiation level at detector points located within or outside a complex radition source geometry. Geometry is describable by zones bounded by intersecting quadratic surfaces with a maximum of six boundary surfaces per zone. Radiation source distributions are describable as separable energy and spatial distributions with internally calculated normalization to provide a point source description of a volumetric source in cylindrical or spherical coordinates. Disc, line, or point sources are describable as source data. The attenuation function for gamma rays is an exponential with a buildup factor approximation to account f multiple scatter. Three optional neutron attenuation functions are included: 1) a modified Albert-Welton function for calculating fast neutron dose rate using neutron removal cross sections; 2) a bivariant polynomial expression for computing neutron spectra using infinite media moments data and neutron removal cross sections; and 3) a monovariant polynomial expression for computing neutron spectra using infinite media moments data and neutron removal cross sections.
4. Method of Solution: A point kernel method using a point source representation of multiple finite volumes representing a volumetric radiation source is used, line-of-sight material attenuation and inverse square spatial attenuation between the source points and detector points is employed. A direct

summation of individual point source results over a user specified breakdown of a volumetric source region into finite volumes is used as the method of integration.

5. Restrictions on the Complexity of the Problem: The KAP VI code is limited to 30 gamma ray groups and 30 neutron groups. The geometry description capability is restricted to zones defined by a maximum of six boundary surfaces with each surface defined by the general quadratic equation or one of its degenerate forms. A total of 100 surfaces and 100 zones are possible in a simple problem. The volumetric source zone in KAP VI problems can be described by a maximum of 4000 finite source volumes each representing a point source. A maximum of 20 radial by 20 axial or polar by 20 azimuthal subdivisions in cylindrical and spherical geometry is allowed.

6. Typical Running Time: The KAP VI code computes approximately 100 source point-to-detector point calculations per second on the UNIVAC 1108 computer. This running time is essentially independent of the number of energy groups and is only dependent upon the calculation of geometry dependent data.

7. Unusual Features of the Code: None

8. Related or Auxiliary Codes: Gamma ray absorption coefficients (cross sections) may be supplied by magnetic tape from the GAMLEG-W[2] code. Neutron and gamma ray source distribution data for neutrons can be supplied on punched cards from the NAGS[2] code. The KAP VI code provides on punched cards detector flux data for use as the effective anisotropic source data in a SCAP[1] code.

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

10. References:

1. R. K. Disney and S. L. Zeigler, WANL-PR(LL)-034, Volume 6, "Point Kernel Techniques," August 1970.
2. 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.

2.2 INPUT DATA DESCRIPTION

The input data to each KAP-VI problem or "change case" consist of three different sets of data. The sets are:

1) Alphanumeric data
2) Integer or fixed point data
3) Real or floating point data

These three data sets are required for each KAP-VI problem or "change case" and the user must enter the required data in each data set. The input deck setup consists of each type of data in the order above.

2.2.1 Input Format

The general card format consists of two data fields. The first field (card columns 1 - 12) is divided into three subfields for all types of data. The second field (card columns 13 - 72) is divided into subfields according to the type of data. The three subfields of the first field are read in a FORTRAN format (I2, I1, I9) and requires the following information is in the corresponding subfield which is common to each type of data set input:

1) The number of pieces or words of data on the card (right adjusted*).
2) A control word specifying that this is the last card of a particular type of data (i.e., 0 or blank means that more cards of a particular type follow; 1 means that is the last card of particular type of data).
3) The address** or data location of the first piece or word data on the card. All subsequent data in the fields on the card, up to and including the total pieces of data specified in the first subfield, are stored in sequence from the address of the first piece or word data.

The second field is divided according to the type of data to be read.

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* Right adjusted means the least significant digit of the number is at the extreme right of the field.

** Address is the relative location of a variable in blank COMMON where the FORTRAN EQUIVALENCE is used to assign data arrays in blank COMMON.

The card format for the alphanumeric or title data is the FORTRAN format (I2, I1, I9, 15A6). The second field (card columns 13 - 72) is divided into 15 subfields with each of the alphanumeric data which are input according to the input instructions.

The relative location or address of the initial four character word in each title array is tabulated and described in Section 2.2.2 and the breakdown of data sections are described. The option to input specific title data was included because of the output flexibility of the program. It must be noted that the user, in specifying a three word title, has the capability of inputting 12 characters of information. In addition, the breakdown of the 180 and 120 character titles into 3 and 2 lines of 15 alphanumeric data words per line (60 characters per line) must be followed by the user to provide clearly titled output results.

The card format for the integer (fixed point) data is the FORTRAN format (I2, I1, I9, 20I3). The second field (card columns 13 - 72) is subdivided into 20, 3 digit subfields with each of the 20 pieces of data input as "right adjusted" integer data.

The address of each piece of data, or the address of each data array, is tabulated and described in Section 2.2.2. The addressing of data internal to each data array is also tabulated and described.

The card format for the real (floating point) data is the FORTRAN format (I2, I1, I9, 5E12.5). The second field (card columns 13 - 72) is subdivided into 5 twelve digit subfields with each of the 5 pieces of data input as real or floating point data.

The relative location or address of each piece of data, or the initial address of each data array, is tabulated and described in Section 2.2.2. The addressing of data internal to each data array is also tabulated and described. A complete KAP-VI punched card input deck for each problem must include at least one data card of each type (alphanumeric, integer, and real). Therefore, the minimum card count for a stacked problem is three cards, one for each type of data with a 1 in column 3 of each card.

The ability to assign the specific address of each data word within any data array allows the user to run stacked problems with minor data changes with a minimum card count.

2.2.2 Input Data Instructions

This section describes the preparation of problem input data for the KAP-VI code. Section 2.3 presents a more detailed description of specific input data preparation. The quantity in slashes represents the number of pieces of data, or the limitation on the range of the input variable. Data array dimensions are specified in the description.

TABLE 2-1

INPUT DATA INSTRUCTIONS FOR KAP-VI CODE

DATA SET 1 - ALPHANUMERIC (TITLE) DATA

Address	Data	Array Dimension	Description
1	TITLE	(45)	Overall problem title (180 alphanumeric characters) which is output at the beginning of the output printing. (Printed 60 characters to a line.)
46	TITLE	(30)	Title information (120 characters) printed preceding the output of results for each source region and all detector points. (Printed 60 characters to a line.)
76	TITLE	(30)	Title information (120 characters) printed preceding the output of results for the subtotal over a selected set of source regions (i.e., the summation over all reactor subregions). (Printed 60 characters to a line.)
106	TITLE	(30)	Title information (120 characters) printed preceding the output of results for the summation over subtotals). (Printed 60 characters to a line.)
	TITLE	(3, 10)	Title information (3 words or 12 characters) associated with gamma ray response output data.
136	TITLE (1)		Gamma ray response No. 1
139	TITLE (2)		Gamma ray response No. 2
142	TITLE (3)		Gamma ray response No. 3
145	TITLE (4)		Gamma ray response No. 4
148	TITLE (5)		Gamma ray response No. 5
151	TITLE (6)		Gamma ray response No. 6
154	TITLE (7)		Gamma ray response No. 7
157	TITLE (8)		Gamma ray response No. 8
160	TITLE (9)		Gamma ray response No. 9
163	TITLE (10)		Gamma ray response No. 10

Table 2-1 (Continued)

Address	Data	Array Dimension	Description
166	TITLE	(3, 10)	Title information (3 words or 12 characters) associated with each neutron response output data. Data order identical to gamma ray response data.
196	TITLE	(3, 10)	Title information (3 words or 12 characters) associated with each Albert-Welton response output data. Data order identical to gamma ray response title data.
	TITLE	(3, 25)	Title information (3 words or 12 characters) for each detector point in the problem:
226	TITLE (1)		Detector point 1
229	TITLE (2)		Detector point 2
232	TITLE (3)		Detector point 3
235	TITLE (4)		Detector point 4
291 - 300	TITLE (25)		Detector point 25

Table 2-1 (Continued)

DATA SET 2 - INTEGER (FIXED POINT) DATA

Address	Data	Array Dimension	Description
1	NGG		Total number of gamma ray groups, E_G/$1 \leq NGG \leq 30$/
2	NGN		Total number of neutron groups, E_n/$1 \leq NGN \leq 30$/
3	MAT		Total number of materials or elements (i. e., an element, H, O, or Fe; or a material, H_2O, UO_2) in the material/composition table. Note: The user may input the data, $\mu_m(E_G)$ for MAT elements, or optionally the program will calculate gamma ray coefficients, $\mu_m(E_G)$, for MATL elements, but not materials (such as H_2O). The coefficients, $\mu_m(E_G)$, calculated by the program are in units of cm^2/gm. The internally generated gamma ray data will appear as the first MATL sets of data in the material/composition table. Therefore, the MAT set of data must correspond up to and including the first MATL set of data. /$1 \leq MAT \leq 20$/ and /$MAT \geq MATL$/
4	NCOMP		Total number of compositions in the material/composition table. /$1 \leq NCOMP \leq 50$/
5	NDET		Total number of detector points to be evaluated for the source region in the problem. The program will accumulate results for multiple source regions for all detector points under the control of the input quantity, ISUM. /$1 \leq NDET \leq 25$/

Table 2-1 (Continued)

DATA SET 2 - INTEGER (FIXED POINT) DATA

Address	Data	Array Dimension	Description
6	NBOUND		Total number of boundary surfaces in the problem geometry. /1 ≤ NBOUND ≤ 100/
7	NREG		Total number of geometric regions or zones in the problem geometry. A region is described by 6 or less boundary surfaces which subdivide the overall problem space. /1 ≤ NREG ≤ 100/
8	NRSPG		Total number of sets of response functions to be applied to the calculated gamma ray flux data at each detector point. /1 ≤ NRSPG ≤ 10/
9	NRSPN		Total number of sets of response functions to be applied to the calculated neutron flux data at each detector point. /1 ≤ NRSPN ≤ 10/
10	NRSPA		Total number of response functions to be applied to the Albert-Welton neutron dose function results each detector point. /1 ≤ NRSPA ≤ 10/
11	MATL		Total number of elements for which gamma ray coefficient sets are to be internally generated by the program. The MATL sets must be the first MAT sets of the material/composition table. If MATL is negative, then a library tape on logical unit 11 is required. /0 ≤ |MATL| ≤ MAT/
19	IBILD		Control word for buildup factor input data. IBILD = 0: input buildup factor polynomial coefficients at location BILD. IBILD≠0: the program internally computes the buildup factor coefficients from the library of data according to the value of IBILD. The allowed values of IBILD for library data are listed in Table 2-2.

Table 2-1 (Continued)

DATA SET 2 - INTEGER (FIXED POINT) DATA

Address	Data	Array Dimension	Description
20	IGAM		Control word for calculation of gamma ray attenuation functions. IGAM = 0: Do not calculate gamma ray attenuation functions. IGAM = 1: Calculate gamma ray attenuation functions.
	INEUT	(3)	Control words for calculation of neutron attenuation functions.
21	INEUT(1)		Control word for Albert-Welton neutron dose calculation. INEUT(1) = 0, do not calculate Albert-Welton result. INEUT(1) = 1, calculate Albert-Welton result (Requires input of XSECN(i, 1), XSECN(i, 2), ALFA, RSPA, and AWSOUR data or data arrays).
22	INEUT(2)		Control word for monovariant polynomial, $f(W_R, E_n)$, neutron spectra calculation. INEUT(2) = 0, do not calculate monovariant polynomial neutron spectra results INEUT(2) = 1, calculate monovariant polynomial neutron spectra results. (Requires input of ASOI(2), NSOUR, ENN, XSEC(i,3), XSNREF, COM, RSPN, XLAM, data arrays)
23	INEUT(3)		Control word for bivariant polynomial, $f(W_R, E_n)$, neutron spectra calculation. INEUT(3) = 0, do not calculate bivariant polynomial neutron spectra results INEUT(3) = 1, calculate bivariant polynomial neutron spectra results. (Requires input of KORD, IORD, ASOI(2), NSOUR, ENN, XSEC(i,3), XSNREF, CON, RSPN, XLAM data arrays.)

Table 2-1 (Continued)

DATA SET 2 - INTEGER (FIXED POINT) DATA

Address	Data	Array Dimension	Description
24	ISCP		Control word for calculation at a detector in the immediate vicinity of source points. (An analytical result is calculated if the path length between a source point and detector point is less than or equal to SMFP mean free paths in the composition number ISCP. (See Section 2.7 for description of technique.) ISCP = 0: Do not calculate analytic result. ISCP >0: Calculate analytic result with the ISCP composition as the source region material in the analytic solution.
25	IZSO		The number of the source zone in which path length calculations for this source region are initiated. IZSO = Source zone number.
26	ISORC		Control word for calculation of all source distribution functions. (See Section 2.7 for description of methods of solving for source data.) ISORC = 0: Do not calculate source distribution data but use previous problem data. ISORC = 1: Calculate new source distribution data from XI, ETA, RS, ZS, PHI, FSI RSIT, ZSIT, FSIT input data.
27	ISRC		Control word for the calculation of source radial distribution data. ISRC = 0: Do not calculate and renormalize input data, but use RS, ZS, PHI, and FSI as point source data. (This option allows the description of one or more discrete point sources.)

Table 2-1 (Continued)

DATA SET 2 - INTEGER (FIXED POINT) DATA

Address	Data	Array Dimension	Description
			Note: The following source radial distribution options are applicable to a cylindrical source geometry.
			ISRC = 1: Uniform or flat source distribution (Does not require FSI input).
			ISRC = 2: Cosine source distribution based on input data, XIs. (Does not require FSI input.)
			ISRC = 3: Source distribution based on a linear variation of input data, FSI, between mesh points, RS.
			ISRC = 4: Source distribution based on input exponential distribution data XIs. (Does not require FSI input.)
			ISRC = 5: Source distribution based on exponential variation of input data, FSI, between mesh points, RS.
			Note: The following source radial distribution options are applicable to a spherical source geometry.
			ISRC = 6: Uniform or flat source distribution. (Does not require FSI input data.)
			ISRC = 7: Source distribution based on a linear variation of input data, FSI, between mesh points, RS.
28	ISZC		Control word for source axial or polar distribution calculations.
			Note: The following source axial distribution options are applicable to cylindrical source geometry.

Table 2-1 (Continued)

DATA SET 2 - INTEGER (FIXED POINT) DATA

Address	Data	Array Dimension	Description
			ISZC = 1: Uniform or flat source distribution. (Does not require FSI input.)
			ISZC = 2: Cosine source distribution based on the input data, ETA. (Does not require FSI input data.)
			ISZC = 3: Source distribution based on the linear variation of input data, FSI, between the mesh points, ZS.
			ISZC = 4: Source distribution based on an exponential variation of the source between mesh points, ZS, and the input data, ETA. (Does not require FSI input data.)
			ISZC = 5: Source distribution based on the exponential variation of the source between mesh points, ZS. (Requires FSI input data.)
			Note: The following source polar distribution option is applicable to a spherical source geometry.
			ISZC = 6: Uniform or flat polar variation. (Does not require FSI input data.)
29	ISTC		Control word for source azimuthal distribution calculations.
			Note: All source azimuthal distributions are assumed to be uniform. The user must use the ISRC = 0 option with all input data calculated externally to the program to do otherwise.
			ISTC = 1: Azimuthal source point spacing from the input data, PHI, with NSO (1) intervals in each radial interval.

Table 2-1 (Continued)

DATA SET 2 - INTEGER (FIXED POINT) DATA

Address	Data	Array Dimension	Description
			ISTC = 2: Azimuthal source point spacing from the input data, PHI, with the number of azimuthal intervals for each radial interval set by the input data, NSO.
			ISTC = 3: Azimuthal source point spacing based on equal azimuthal intervals; the number of intervals is set by the input data, NSO.
30	ISIT		Control word for source distribution interpolation calculation.
			ISIT = 0: Do not interpolate RSIT, ZSIT, FSIT input data to obtain FSI at RS and ZS.
			ISIT = 1: Interpolate RSIT, ZSIT, FSIT input data to obtain FSI at RS and ZS.
31	ISUM		Control word for summation of the contribution of individual source regions to the detector response at each detector point.
			ISUM $<$ 0: Initialize the subtotal (intermediate) and total summary results by setting all values to 0. 0. This procedure is necessary for subsequent summations over individual source region results. ISUM is set equal to the absolute value of the input value of ISUM after initialization process.
			ISUM = 0: Do not include results from this individual source region in the subtotal or total summary results.
			ISUM = +1: Add individual source region results to subtotal and total summary results.
			ISUM = +2: Add this individual source region to the subtotal and total summary results, print the subtotal summary results, and then set all subtotal summary results to zero.

Table 2-1 (Continued)

DATA SET 2 - INTEGER (FIXED POINT) DATA

Address	Data	Array Dimension	Description
			ISUM = +3: Add this individual source region to the subtotal and total summary results, print the subtotal and total summary results to zero. NOTE: If ISUM = 3, then the gamma ray and neutron total summary results for the first response function are output on punched data cards in the FORTRAN format 6E12.5 for use in the SCAP code (see Section 3.2).
32	IOUT(1)		Control word for printing input data. IOUT(1) = 0: Do not print input data. IOUT(1) = 1: Print card images of input data. IOUT(1) = 2: Print card images and organized input data NOTE: Normalized source distribution data are printed only when IOUT(1) = 2.
33	IOUT(2)		Control word for printing of output data. IOUT(2) = 0: Print all output data for each individual source region. IOUT(2) = 1: Do not print individual source region results.
	KORD	(3)	Degree or order for each set of the neutron moments method bivariant polynomial data in the independent variable, energy (E_n).
35	KORD(1)		Degree or order of the first set of coefficients for the energy range, BKP(1) to BKP(2).
36	KORD(2)		Degree or order of the second set of coefficients for the energy range, BKP(2) to BKP(3).
37	KORD(3)		Degree or order of the third set of coefficients for the energy range, BKP(3) to BKP(4).

Table 2-1 (Continued)

DATA SET 2 - INTEGER (FIXED POINT) DATA

Address	Data	Array Dimension	Description
	IORD	(3)	Degree or order for each set of the neutron moments method bivariant polynomial data in the independent variable, depth penetration (W_R).
40	IORD(1)		Degree or order of the first set of coefficients for the energy range, BKP(1) to BKP(2).
41	IORD(2)		Degree or order of the second set of coefficients for the energy range, BKP(2) to BKP(3).
42	IORD(3)		Degree or order of the third set of coefficients for the energy range, BKP(3) to BKP(4).
50	LSO		Total number of radial mesh intervals in the source region description. /$1 \leq LSO \leq 20$/
51	MSO		Total number of axial or polar mesh intervals in the source region description. /$1 \leq MSO \leq 20$/
	NSO	(20)	Total number of azimuthal mesh intervals for each radial interval in the source region description. /$1 \leq NSO(i) \leq 20$/
52	NSO(1)		Total number of azimuthal mesh intervals in radial interval number 1 or if, ISTC = 1, the total number of intervals in each radial interval.
53	NSO(2)		Total number of azimuthal mesh intervals in radial interval 2.
.	.		.
.	.		.
.	.		.

Table 2-1 (Continued)

DATA SET 2 - INTEGER (FIXED POINT) DATA

Address	Data	Array Dimension	Description
71	NSO(20)		Total number of azimuthal mesh intervals in radial interval 20.
75	LSIT		Total number of radial source distribution input data values, RSIT and FSIT. This data, RSIT and FSIT, is used for interpolation of the source distribution data, FSI, at the mesh points, RS. /1≤ LSIT ≤51/ NOTE: The data, RSIT and FSIT, can be obtained on cards from the NAGS code.
76	MSIT		Total number of axial source distribution input data values, ZSIT and FSIT, to be used for interpolation of source distribution data, FSI, at the mesh points, ZSI. /1≤ MSIT ≤51/ NOTE: The data, ZSIT and FSIT can be obtained on cards from the NAGS code.
	NEQBD(j)	(100)	Surface equation type number for each boundary surface, j, in the problem. (The surface equations and their respective type number are presented in Table 2-3 along with the required surface coefficient input data - ABD, BBD, CBD, DBD, XOBD, YOBD, ZOBD) /1 ≤NEQBD(j) ≤ 6/
100	NEQBD(1)		Surface type number for surface No. 1.
101	NEQBD(2)		Surface type number for surface No. 2.
.	.		.
.	.		.
.	.		.
199	NEQBD(100)		Surface equation type number for surface No. 100.

Table 2-1 (Continued

DATA SET 2 - INTEGER (FIXED POINT) DATA

Address	Data	Array Dimension	Description
	NBNDZN(i)	(100)	The total number of boundaries or surfaces defining each zone, i, in the problem. Each zone must have at least one boundary and no more than six boundaries. /1 ≤ NBNDZN(i) ≤ 6 / Note: The sign (±) of NBNDZN(i) denotes whether the zone is an outside or last zone and the user must specify this sign. If NBNDZN is negative, the zone is an outside or last zone to be calculated on the ray trace to a detector.
200	NBNDZN(1)		Total number of boundary surfaces for zone No. 1.
201	NBNDZN(2)		Total number of boundary surfaces for zone No. 2.
.	.		.
.	.		.
.	.		.
299	NBNDZN(100)		Total number of boundary surfaces for zone No. 100.
	NCMPZN(i)	(100)	The composition number of the mixture of materials in zone, i, for each zone in the problem. NOTE: If NCMPZN(i) is input as a negative value, there is no buildup calculated for the mean free paths in the zone, i. Only uncollided attenuation is calculated for zone i.
300	NCMPZN(1)		Composition number in zone 1.
301	NCMPZN(2)		Composition number in zone 2.
.	.		.
.	.		.
.	.		.

Table 2-1 (Continued)

DATA SET 2 - INTEGER (FIXED POINT) DATA

Address	Data	Array Dimension	Description
399	NCMPZN(100)		Composition number in zone 100.
	LBD(j,i)	(6,100)	The boundary surface numbers, j, for each zone, i. The user must specify NBNDZN(i) surface numbers for each zone, i, and the surfaces must totally enclose the zone or region in the problem. Outside zones can be described as single boundary zones. Note: The KAP-VI program will automatically assign all ambiguity indices (+ or -) of each surface, j, in relation to each zone, i.
500	LBD(j,1)		Surface numbers, j = 1, NBNDZN(1), for zone 1.
506	LBD(j,2)		Surface numbers, j = 1, NBNDZN(1), for zone 2.
.	.		.
.	.		.
.	.		.
1094	LBD(j,100)		Surface numbers, j = 1, NBNDZN(1), for zone 100.
	NTRYZN(j,i)	(6,100)	The zone identification number for each boundary j, of each zone, i, which defines the zone encountered upon crossing each boundary of the zone, i. There is a one-to-one correspondence between LBD and NTRYZN. Note: If more than one zone can be entered upon crossing boundary, j, the user can minimize problem running times by specifying the zone entered the most times, or if this cannot be determined, the zone with the lower identification number.
1100	NTRYZN(j,1)		Zone number, j = 1, NBNDZN(1), for zone 1.

Table 2-1 (Continued)

DATA SET 2 - INTEGER (FIXED POINT) DATA

Address	Data	Array Dimension	Description
1106	NTRYZN(j,2)		Zone number, j = 1, NBNDZN(1) for zone 2
.	.		.
.	.		.
.	.		.
1694	NTRYZN(j,100)		Zone number, j = 1, NBNDZN(1), for zone 100.

Table 2-1 (Continued)

DATA SET 3 - REAL (FLOATING POINT DATA)

Address	Data	Array Dimension	Description
	ASOI	(2)	Gamma ray and neutron source normalization constants. The input constants, ASOI, must be dimensionally consistent with GSOUR, NSOUR, and AWSOUR. (See Section 2.7.4 3 for details.)
1	ASOI(1)		Gamma ray source normalization constant.
2	ASOI(2)		Neutron source normalization constant. Note: If ASOI(2) is input as 0.0, the program assumes ASOI(2) = ASOI(1) and all gamma ray source distribution data, FSI, are also used for neutron source calculations.
	XI	(2)	Radial source distribution constants used in the truncated cosine or exponential source distribution function.
			For truncated cosine, (required when ISRC = 2):
3	XI(1)		$=\pi/2B$, where B is the extrapolated radius R* of the radial cosine function describing the source distribution.
4	XI(2)		= C, where C is the radial coordinate of the center of the source region, R=0.0, for a source centered in the coordinate system.
			For exponential (required when ISRC = 4):
3	X(1)		$= f(R_o)$, the source value at the left boundary radius, R_o
4	XI(2)		$= \sigma$, the slope of the source distribution in the region.
	ETA	(2)	Axial source distribution constants used in the truncated cosine or exponential source distribution function.

Table 2-1 (Continued)

DATA SET 3 - REAL (FLOATING POINT DATA)

Address	Data	Array Dimension	Description
			For truncated cosine (required when ISZC = 2)
5	ETA(1)		$= \frac{\pi}{B}$, where B is the extrapolated height, H*, of the axial cosine function describing the source distribution.
6	ETA(2)		= C, where C is the axial coordinate of the center of the source region, C = H*/2, for a source whose base is at the origin of the coordinate system.
			For exponential (required when ISZC = 4)
5	ETA(1)		= $f(Z_o)$, the source value at the left axial boundary, Z_o.
6	ETA(2)		= σ, the slope of the source distribution in the region.
7	RS(i)	(21)	Radial dimensions of the source region mesh lines. /LSO + 1 values/
28	ZS(m)	(21)	Axial or polar dimensions of source region mesh lines. /MSO + 1 values/
	PHI(n,i)	(21,20)	Azimuthal dimensions of source region mesh lines for each radial interval, i.
49	PHI(n,1)		Dimensions of radial interval No. 1, (NSO(1) + 1 values) NOTE: If ISTC = 3, input PHI(1,1) and PHI(2,1) as 0.0 and 3.15149.
70	PHI(n,2)		Dimensions of radial interval No. 2, (NSO(2) + 1 values)
.	.		.
.	.		.
.	.		.

Table 2-1 (Continued)

DATA SET 3 - REAL (FLOATING POINT DATA)

Address	Data	Array Dimension	Description
448	PHI(n,20)		Dimensions of radial interval No. 20, /NSO(20) + 1 values/ Note: PHI(n,i) for i greater than 1 are required only when for ISTC = 2
	FSI	(21,22,2)	Source distribution data for radial, axial, or polar, and azimuthal distribution for both gamma ray, K = 1, and neutron, K = 2, source data.
470	FSI(l,1,1)		Gamma ray radial source data (required when ISRC = 3 or 5) /LSO + 1 values/
491	FSI(m,2,1)		Gamma ray axial or polar source data (required when ISZC = 3 or 5) /MSO + 1 values/
	FSI(n,3,1)		Gamma ray azimuthal data for each radial interval, /NSO(1) + 1 values/ Note: FSI(n,3,1) is required input only for the case when the user specifies all source data FSI as input (i.e., a unit point source is input by specifying ISORC = 1, ISRC =0, FSI(470) = 1.0, FSI(491) = 1.0, FSI(512) = 1.0)
512	FSI(1,3,1)		Gamma ray azimuthal data for radial interval No. 1.
533	RSI(2,3,1)		Gamma ray azimuthal data for radial interval No. 2.
.	.		.
.	.		.
.	.		.
931	FSI(20,3,1)		Gamma ray azimuthal data for radial interval No. 20.

Table 2-1 (Continued)

DATA SET 3 - REAL (FLOATING POINT DATA)

Address	Data	Array Dimension	Description
932	FSI(1,1,2)		Neutron source distribution data input which is identical in order to the gamma ray data, but with all addresses increased by 462. Note: If ASOI(2) is input as 0. 0, then FSI(I,1,2) = FSI(I,1,1)
1400	GSOUR	(30)	Gamma ray source by energy group, ENG. Note: GSOUR must be dimensionally consistent with ASOI(1), so that GSOUR(k)· ASOI(1) will provide the units of particles or MeV/cm^3–sec. The NAGS code can provide at user option the GSOUR data in the KAP-VI punched data card format.
1430	NSOUR	(30)	Neutron source by energy group, ENN. Note: NSOUR must be dimensionally consistent with ASOI(2). These quantities provide the user with the capability to input group dependent integration factors (energy band widths) and must not be construed as neutron source spectra.

The following input data (ABD, BBD, CBD, XOBD, YOBD, ZOBD, DBD) are the surface equation coefficients and constants for each boundary (1 - 100). This input depends on the surface quation type as specified in the NEQBD array. The surface equation types which are in the program are the general quadratic equation, and five of the common degenerate forms as shown in Table 2-3.

1460	ABD	(100)	Surface equation coefficient constant, A, for surfaces 1 - 100.
1560	BBD	(100)	Surface equation coefficient, B, for surfaces 1 - 100.
1660	CBD	(100)	Surface equation coefficient, C, for surfaces 1 - 100.
1760	XOBD	(100)	Surface equation constant, X_0, for surfaces 1 - 100.

Table 2-1 (Continued)

DATA SET 3 - REAL (FLOATING POINT DATA)

Address	Data	Array Dimension	Description
1860	YOBD	(100)	Surface equation constant, Y_0, for surfaces 1 - 100.
1960	ZOBD	(100)	Surface equation constant, Z_0, for surfaces 1 - 100.
2060	DBD	(100)	Surface equation coefficient D, for surfaces 1-100. Note: To eliminate errors in path length calculations, the program automatically squares the input quantity, D, foı surface equation types 2 and 3 to provide absolute matching of surface intersections.
	XYZ(j,i)	(3,100)	Cartesian coordinates of the point internal to each zone, i, described by the input data, LBD. There are 3 x NREG required input values. These data are used in computing the ambiguity indices (+ or -) of each surface in relation to the zone and extreme caution must be used in determining input values.
2160	XYZ(j,1)		(X_p, Y_p, Z_p) for zone 1.
2163	XYZ(j,2)		(X_p, Y_p, Z_p) for zone 2.
.	.		.
.	.		.
.	.		.
2457	XYZ(j,100)		(X_p, Y_p, Z_p) for zone 100.
	COMP(m,n)	(20,50)	Composition matrix (densities or volume fractions) according to the materials or elements, m, in the problem.

Table 2-1 (Continued)

DATA SET 3 - REAL (FLOATING POINT DATA)

Address	Data	Array Dimension	Description
2460	COMP(m,1)		COMP(m,1): data for all materials, m, in composition 1.
2480	COMP(m,2)		COMP(m,2): data for all materials, m, in composition 2.
. . .	. . .		. . .
3440	COMP(m,50)		COMP(m,50): data for all materials, m, in composition 50.
3460	ENN	(30)	Representative energy of each neutron group.
	XSECN(m,i)	(20,3)	Data for the Albert-Welton and neutron spectra functions.
3490	XSECN(m,1)		Neutron removal cross sections for each material for use with the Albert-Welton function.
3510	XSECN(m,2)		Constants (η 's) for each material for use with the Albert-Welton function.
3530	XSECN(m,3)		Neutron removal cross sections for each material for use with the neutron spectra function.
3550	XSNREF		Neutron removal cross section for the material for which the neutron moments data is input (reference material removal cross section).
3551	ALFA	(7)	Constants (α's) for the Albert-Welton function.
3558	AWSOUR		Source strength to be applied to the Albert-Welton kernel. Note: AWSOUR must be dimensionally consistent with ASOI(2).

Table 2-1 (Continued)

DATA SET 3 - REAL (FLOATING POINT DATA)

Address	Data	Array Dimension	Description
3560	ENG	(30)	Representative energy of each gamma ray source group.
	XSECG(k,m)	(30,20)	Gamma ray absorption coefficients for each group k, and each material, m, in the problem. The program will generate these data from the data on magnetic Tape 11 if MATL < 0 or from evaluation of bivariant polynomials if MATL > 0. If MATL ≠ 0, then input values of ZAT are required.
3590	XSECG(k,1)		Coefficients for each group k, material 1.
3620	XSECG(k,2)		Coefficients for each group k, material 2.
.	.		.
.	.		.
.	.		.
4160	XSECG(k,30)		Coefficients for each group k, material 30.
	BILD(1,k)	(4, 30)	Gamma ray cubic polynomial buildup coefficients for each gamma ray group, k. (Required input when IBILD = 0.) Note: The program will internally compute these data if IBILD > 0.
4190	BILD(1,1)		$\beta_0, \beta_1, \beta_2, \beta_3$ for group 1.
4194	BILD(1,2)		$\beta_0, \beta_1, \beta_2, \beta_3$ for group 2.
.	.		.
.	.		.
.	.		.
4306	BILD(1,30)		$\beta_0, \beta_1, \beta_2, \beta_3$ for group 30.

Table 2-1 (Continued)

DATA SET 3 - REAL (FLOATING POINT DATA)

Address	Data	Array Dimension	Description
4310	SMFP		Total mean free path of source zone material (source composition ISCP) used in determining the exclusion sphere volume for source points adjacent to detector points. This quantity is used in the empirical solution of the gamma ray flux for detector points internal to source regions. (See Section 2.7.8.)
4311	TMFP		The limit or maximum range of mean free paths of gamma ray depth penetration for cubic polynomial buildup data. The program calculates buildup only on TMFP (or less) mean free paths. If the mean free path exceeds TMFP, the program sets the mean free path equal to TMFP. The program assumes TMFP = 20, if TMFP is not input.
4312	EPSLN		Surface equation-path length calculation error limit used in determining if a surface is crossed. If the test fails, an error statement is given. Note: EPSLN is internally set as 1.0×10^{-6} and is not required as input if the user accepts this value.
4313	FUDGE		Surface equation-path length calculation step quantity used in providing a means for the calculation to cross a boundary. If two steps are unsuccessful, an error statement is given. Note: FUDGE is internally set as 1.0×10^{-3} and is not required as input if the user accepts this value.
4314	BKP(i)	(4)	For Monovariant Polynomial Neutron Spectra Data: (Required input when INEUT(2) = 1) The neutron depth penetration, gm/cm^2, which is the breakpoint between the two sets of monovariant moments method data. Only BKP(1) is required.

Table 2-1 (Continued)

DATA SET 3 - REAL (FLOATING POINT DATA)

Address	Data	Array Dimension	Description
			For Bivariant Polynomial Neutron Spectra Data: (Required input when INEUT(3) = 1):
			The neutron energy breakpoints for the applicability of the bivariant polynomial neutron spectrum data. BKP(1-4) must be in order of decreasing energy and the last values 2, 3 or 4 must not be zero (e.g., for only one set of polynomial data, BKP(1) = E (higher) and BKP(2,3, and 4) = E (lower). E (MEV)
	COM	(5,30,2)	(Required input when INEUT (2) = 1):
			Neutron spectra monovariant polynomial coefficients for NGN groups. These data, which are evaluated as a function of depth penetration (W, gm/cm^2 of equivalent neutron attenuation), is assumed to be applicable in the range of $0.0 \leq W \leq 120.0$ gm/cm^2. The two sets of input data divide this range into, $0.0 \geq W \geq BKP(1)$ and $BKP(1) \geq W \geq 120.0$. For any depth penetration in excess of 120.0 gm/cm^2, the group dependent λ's (input quantities, XLAM) are used as simple exponential attenuation as, exp $[-\lambda(W - 120.0)]$.
4320	COM(i,1,1)		COM(1-5): C_5, C_4, C_3, C_2, C_1 for group 1, and $W \leq BKP(1)$.
4325	COM(i,2,1)		COM(1-5): C_5, C_4, C_3, C_2, C_1 for group 2, and $W \leq BKP(1)$.
.	.		.
.	.		.
.	.		.
4460	COM(i,30,1)		COM(1-5): C_5, C_4, C_3, C_2, C_1 for group 30, and $W \leq BKP(1)$.

Table 2-1 (Continued)

DATA SET 3 - REAL (FLOATING POINT DATA)

Address	Data	Array Dimension	Description
4470	COM(i,1,2)		COM(1-5): C_5, C_4, C_3, C_2, C_1 for group 1, and W$\geq$ BKP(1).
4475	COM(i,2,2)		COM(1-5): C_5, C_4, C_3, C_2, C_1 for group 2, and W$\geq$BKP(1).
.	.		.
.	.		.
.	.		.
4615	COM(i,30,2)		COM(1-5): C_5, C_4, C_3, C_2, C_1 for group 30, and W$\geq$BKP(1)
	CON	(5,5,4)	(Required input when INEUT(3) = 1): Neutron spectra bivariant polynomial coefficients. These data, which are evaluated as a function of depth penetration, W, and neutron energy, E_n, are assumed applicable over the entire range of W $\geq$120.0 gm/cm^2. The four sets of data divide the energy range into four intervals as determined by BKP(1-4). Calculations for W in excess of 120.0 gm/cm^2 are discussed above in the monovariant polynomial description.
4620	CON(5,5,1)		CON(1-25): C_1, C_2, C_3, C_4, C_5. . . . . C_{25} for BKP1 $\geq$E $\geq$BKP2.
4645	CON(5,5,2)		CON(1-25): C_1, C_2, C_3. . . . . C_{25} for BKP2$\geq$E$\geq$BKP3.
4670	CON(5,5,3)		CON(1-25): C_1, C_2, C_3. . . . . C_{25} for BKP3$\geq$ E$\geq$BKP4.
.	.		.
.	.		.
.	.		.
4695	CON(5,5,4)		CON(1-25): C_1, C_2, C_3. . . . . C_{25} for E$\geq$BKP4.

Table 2-1 (Continued)

DATA SET 3 - REAL (FLOATING POINT DATA)

Address	Data	Array Dimension	Description
4720	XLAM	(30)	(Required input when INEUT(2) or INEUT(3) = 1): Values of $\lambda(E_n)$ for each neutron energy group for use in extrapolating either the monovariant of bivariant neutron spectra data for values of $W \geq 120.0$ gm/cm^2.
	RSPG	(30,10)	Group-dependent gamma ray response functions. The user must input at least one set of data. If collided and uncollided energy flux is desired as output data, one set of RSPG values must be input as 1.0. The code will provide NRSPG sets of data, and the sum or total over NGG groups for each response function.
4750	RSPG(k,1)		Response function No. 1, for each energy group, k.
4780	RSPG(k,2)		Response function No. 2, for each energy group, k.
.	.		.
.	.		.
.	.		.
5020	RSPG(k,10)		Response function No. 10, for each energy group, k.
	RSPN	(30,10)	Group dependent response functions for the neutron spectra data. The user must input at least one set of data. If the total (sum over groups) response is desired, (i.e., total neutrons/cm^2-sec) the energy width for each group must appear in RSPN or in the input neutron group-dependent source data NSOUR.
5050	RSPN(i, 1)		RSPN is input in the same order as RSPG starting with address, 5050.

Table 2-1 (Continued)

DATA SET 3 - REAL (FLOATING POINT DATA)

Address	Data	Array Dimension	Description
5350	RSPA	(1,10)	Response functions for the Albert-Welton function. The user must input at least one value of RSPA (i.e., RSPA (1) = 1.0). The program will provide NRSPA values of output.
	RCORD	(3,25)	Detector point coordinates (R_D, Z_D, θ_D) for NDET detector points. The detector points must not lie on a boundary of a zone. A maximum of 25 detector points per problem are permitted.
5360	RCORD(i,1)		(R_D, Z_D, θ_D), for detector No. 1.
5363	RCORD(i,2)		(R_D, Z_D, θ_D), for detector No. 2.
5369	RCORE (i, 3)		(R_C, Z_D, θ_D), for detector No. 3.
.	.		.
.	.		.
.	.		.
5432	RCORD (i, 25)		(R_D, Z_D, θ_D), for detector No. 25.
5510	SSOT	(3)	Source region translation coordinates (X_T, Y_T, Z_T). The values of SSOT may be used to translate the source region in the problem geometry so that the input source data can be relative to (0,0,0).
5513	ZAT	(20)	(Required only if MATL $\neq$ 0) Atomic number (electrons per atom) of each element for which gamma ray absorption coefficients, are to be calculated by the program. The calculated values, in units of cm^2/gm, will appear as the first MATL sets of gamma ray absorption coefficients. If coefficients are input in conjunction with calculated values, then the input values must be the |MATL| + 1 to MAT sets of values.

Table 2-1 (Continued)

DATA SET 3 - REAL (FLOATING POINT DATA)

Address	Data	Array Dimension	Description
			If MATL is less than zero, the values of ZAT are used to read the GAMLEG-W library tape. When MATL< 0, the values of ZAT must be in the order of the data in Table 2-4.
			(The following required only if ISORC = 1)

NOTE: The NAGS code can provide at user option the RSIT, ZSIT, and FSIT data in the KAP VI punched data card format along with the GSOUR (Address 1400) data.

Address	Data	Array Dimension	Description
5533	RSIT	(51)	Radial coordinates of source distribution data to be used in the source interpolation routine. There are LSIT values required. The range of RSIT should be greater than or equal to the range of the radial values, RS, so that only interpolation of data is used.
5584	ZSIT	(51)	Axial coordinates of the source distribution data to be used in the source interpolation routine. There are MSIT values required. The range of ZSIT should be greater than or equal to the range of the axial values, ZS, so that only interpolation is used.
	FSIT(i, j, k)	(51,2,2)	Source distribution data to be used in the source interpolation routine. There are LSIT and MSIT values required. Source interpolation is calculated for both gamma ray and neutron source distributions.
5635	FSIT(i,1,1)		Radial gamma ray source data.
5686	FSIT(i,2,1)		Axial gamma ray source data.
5737	FSIT(i,1,2)		Radial neutron source data.
5788	FSIT(i,2,2)		Axial neutron source data.

TABLE 2-2

LIBRARY OF BIVARIANT POLYNOMIAL
DATA FOR GAMMA RAY BUILDUP COEFFICIENT EVALUATION

IBILD (KAP IV), NBT (SCAP) Value	Material	Buildup Type	Applicable Ranges E_G(lower)	E_G(upper)	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

TABLE 2-3

GEOMETRY BOUNDARY SURFACE EQUATION TYPES AND REQUIRED INPUT

Boundary Equation Type (NEQBD)	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	$A(x-X_o)^2 + B(y-Y_o)^2 + C(z-Z_o)^2 - D^2 = 0.0$	$A, B, C, X_o, Y_o, Z_o, D$
3	$(x-X_o)^2 + (y-Y_o)^2 + D^2 = 0.0$	X_o, Y_o, D
4	$x - D = 0.0$	D
5	$y - D = 0.0$	D
6	$z - D = 0.0$	D

TABLE 2-4

GAMMA RAY CROSS SECTION LIBRARY DATA (GAMLEG-W) [IF MATL < 0, (KAP) or NL = 1 (SCAP)]

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

2.3 DETAILED INPUT DATA INFORMATION

Detailed input data description on the required KAP VI input data are not provided. The user is referred to the description of the input data in Section 2.2 and the description of the code logic and method of solution in Sections 2.6 and 2.7 for details.

2.4 PROBLEM SETUP INFORMATION

The setup of a KAP VI code problem is described in this section with a sample problem setup and input punched card listing in Section 2.4.4. This section is intended to define the deck setup forthe MSFC UNIVAC 1108 computer system. The MSFC version of the KAP VI code resides on a production tape and is used by loading the code from tape with control cards preceding the input deck. The use of tape or disk files, running time, and error messages are described in the following sections.

2.4.1 Tape Assignments

The KAP VI code requires a maximum of four magnetic tape or disk files for a specific problem. For a majority of problems only three files are required. The file assignments are as follows:

Tape 5 Input Disk

Tape 6 Output Disk

Tape 7 Punched Output Disk

Tape 11 Cross Section Library
Input Tape
/Required only if MATL <0/

The Tape 11 input tape is the tape produced by GAMLEG-W and contains the pair production and photoelectric pointwise cross section data for elements in the element/ composition table specified as KAP VI input (see Section 2.2.2 and 2.7.7).

2.4.2 Running Time

The required running time for a given KAP VI problem on the MSFC UNIVAC 1108 computer is mainly dependent upon the number of source points per region, number of regions, and the number of detectors. The estimate of the required CPU time is obtained by calculating the total number of source point-to-detector point calculations for each source region as follows:

$$N_z = \sum \left(MSO_z * \sum_{i=1}^{LSO_z} NSO_{i,z} \right)$$

where N_z is the number of source points in a source zone,

MSO_z is the input value of the number of axial or polar mesh intervals in the source zone

$NSO_{i,z}$ is the number of azimuthal mesh intervals in each radial mesh interval i where i is from 1 to the input value LSO, the number of radial mesh intervals in the source zone.

The total running time for a KAP VI problem with N_z source zones is then estimated as;

$$t(\text{CPU seconds}) = \frac{NDET * \sum_{z=1}^{N_z} N_z}{100}$$

where: NDET is the number of detectors in the KAP VI problem, and

N_z is the number of source zones.

2.4.3 Error Messages

A number of KAP VI code generated error messages may be encountered in running a KAP VI problem. These messages are primarily due to the incorrect problem input. The error messages are generally self-explanatory.

Message	Explanation
Error in input data cards as follows (card image printed)	Number of pieces of data specified on the card incorrect or address specified on the card incorrect for the type of data being read.
Error in source distribution (1/Gamma, 2/neutron) . . . . x point . . . . y.	Input quantity FSI (y, 1, x) $\leq$ 0. 0 where y is radial interval number
Error in axial source distribution (1/gamma, 2/neutron) . . . . x, point . . . . y.	Input quantity FSI (y,2,x) $\leq$ 0. 0 where y is axial interval number
Number of gamma ray groups in error	Input quantity NGG $\leq$ 0 or NGG > 30
Number of gamma ray responses in error	Input quantity NRSPG $\leq$ 0 or NRSPG > 10
Gamma ray responses are all zero	Input quantities RSPGs equal zero for all groups.
Gamma ray source must be non-zero and positive	Input quantity ASO(1) $\leq$ 0. 0
Gamma ray source spectra must be non-zero and positive	Input quantity GSOUR $\leq$ 0. 0
All gamma ray energies must be non-zero and positive	One or more input quantity ENG = 0. 0
Gamma ray coefficient must not all be zero and non-positive	One or more input quantity XSECG = 0. 0 Check MAT and MATL option and related input
Number of gamma ray buildup coefficients are specified	One or more input quantities BUILD = 0.0 Check IBILD option and related input.
All geometry parameters (LBD and NTRYZN) must be non-zero	Input quantities LBD = 0 or NTRYZN = 0
Receiver point coordinates for point x are incorrect R = y.	y $\leq$ 0. 0 where x = detector number y = radial coordinate of detector in error

Message	Explanation
The length routine has experienced error number x.	x = 1. A zone cannot be located for a point on the line-of-sight. Check geometry x = 2. A boundary crossing on the line-of-sight cannot be found. Check location of source point and detector point with relation to geometry.
Error in breakpoints for range of bivariant polynomials for moments data, energy group . . . _, energy = _, energy limit = _	Check input quantities ENN and BKP.
A total flux of zero was obtained for the problem. The problem was terminated.	Check input quantities RS, XSECG, COMP.

2.4.4 Sample Problem Input

A sample problem for the KAP VI code has been included in this section to illustrate the flexibility of the input formats and the problem deck setup. The sample problem geometry is a nuclear rocket engine - nuclear subsystem (i.e., reactor). The nuclear subsystem geometry is described in Volume 1 of this report. The gamma ray and neutron source data used as input are the punched card output of the NAGS code (See Volume 3 of this report).

The calculation performed by this sample problem is the calculation of the neutron and gamma ray flux levels at detector points on a meridian ring. The sample problem consists of a series of eleven detector points but for brevity the number of detectors were limited to one for this sample problem. A listing of the sample problem input card deck is in Table 2-5.

TABLE 2-5

SAMPLE PROBLEM CARD INPUT FOR THE KAP-VI CODE

```
15     1 MSFC SAMPLE PROBLEM - SOURCE DATA FROM NAGS
15    16                     - GEOM. - 75 D. PROP. TANK
15    31                     - MERIDIAN RING COS(A)=1.0 TO 0.9
15    76   CORE REGION - TOTAL
15    76   EXTRA CORE REGIONS - TOTAL
15   106   NUCLEAR SUBSYSTEM - TOTAL
 3   136 MEV/CM2-SEC
 3   139 RADS(C)/HR
 3   142   REM/HR
 3   166 TOTAL
 3   169 E.GT.1MEV
 3   172 E.LT.1MEV
 3   175 REM/HR
 3   178(RADS-T)/HR
 3   196 RADS(E)/HR
 3   226 A=0.998
 3   229 A=0.986
 3   232 A=0.978
 3   235 A=0.970
 3   238 A=0.966
 3   241 A=0.954
 3   244 A=0.946
 3   247 A=0.938
 3   250 A=0.922
 3   253 A=0.910
 3   256 A=0.902
151   46 REGION NO.  1 RADIAL CORE CENTER REGION      P1
11     1 13 27 12 12  1 33 34  3  5  1 12
11    19  1  1  1  0  1  0  1  1  3  3  3
 4    30  1 -1  2  0
 3    35  3  2  3
 3    40  2  3  3
20   100  6  2  2  2  6  6  6  6  6  6  2  2  2  6  2  2  2  3  3  3
13   120  3  6  6  6  6  6  6  6  3  3  3  3  3
13   200  3  4  4  4  3  3  4  3  3  3 -4  4  3
20   213  3  3  2  3  4  4  4  3  3  3  4  4  4  3  2  3  3  4 -2 -1
 1   233 -2
13   300  1  1  2  3  4  6  4  5  7  3 12 12 12
20   313  8  9 10 10  9  8 12 11 11 11  9  8 12 11 11  9  8 12 12 12
 1   333 12
18   500 22 23 29          22 29 23 30       22 30 23 32
18   518 22 32 27 33       23 24 32          24 25 31
18   536 24 31 25 32       25 26 32          26 27 32
18   554 27 28 33          28  2  5 21       22 33 28 21
18   572  1 22 21           2  5  3           3  5  4
18   590  4  5              5 15  6           5 16  8 15
18   608  5 17  8 16        5 21  8 17        6 15  7
18   626  7 15  8           8 18  9           8 19 10 18
```

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TABLE 2-5 (Continued)

18	644	8 20 10 19	8 21 10 20		9 18 10		
18	662	10 11	10 12 11		10 13 12		
18	680	10 21 14 13	14 21		21		
6	698	21 1					
18	1100	13 5 2	13 1 5 3		13 2 5 4		
18	1118	13 3 10 12	1 6 4		5 8 7		
18	1136	5 6 8 4	6 9 4		8 10 4		
18	1154	9 11 12	10 14 20 33		13 4 11 33		
18	1172	34 1 33	11 19 15		14 18 16		
18	1190	15 17	16 18 21		15 19 24 17		
18	1208	14 20 25 18	11 33 26 19		17 18 22		
18	1226	21 18 23	22 24 27		18 25 29 23		
18	1244	19 26 30 24	20 33 31 25		23 24 28		
18	1262	27 29	24 30 28		25 31 29		
18	1280	26 33 32 30	31 33		11		
6	1298	33 34					
2	50	7 14					1
7	52	2 4 6 8	10 12 14				1
21	75	14 29					
2	1	1.0	0.8309				
5	7	0.0	10.0	20.0	25.0	30.0	R 1
3	12	35.0	40.0	43.5			R 1
5	28	0.0	10.0	20.0	30.0	40.0	A1,2,3,4
5	33	50.0	60.0	70.0	80.0	90.0	A1,2,3,4
5	38	100.0	110.0	120.0	130.0	137.16	A1,2,3,4
2	49	0.0	3.14159235				
50	1400	8.42206E-03	6.90293E-03	2.93810E-02	7.45449E-02	2.57404E-01	
50	1405	4.73163E-01	2.99288E-01	4.11821E-01	5.38622E-01	7.26046E-01	
30	1410	9.74204E-01	1.32113E&00	5.99359E-01			
5	1430	1.235	2.47	2.47	2.47	2.47	
5	1435	2.47	2.47	1.482	1.976	1.482	
5	1440	9.888 -1	7.41 -1	4.94 -1	3.705 -1	2.47 -1	
5	1445	2.47 -1	2.47 -1	1.358 -1	2.47 -2	2.47 -2	
5	1450	2.47 -2	2.47 -2	2.47 -2	2.47 -2	2.47 -2	
2	1455	2.47 -2	1.235 -2				
5	2060	-1000.0	261.54	256.46	256.04	7.7697	&2
5	2065	898.5	1288.5	1655.84	2188.5	2409.84	
5	2070	487.26	487.68	492.76	2756.0	0.0	
5	2075	0.0	0.0	487.26	487.68	492.76	
5	2080	1000.0	0.0	137.16	139.7	154.94	
5	2085	193.04	215.90	218.44	43.5	50.8	
3	2090	55.88	63.5	66.04			
3	1461	1.0	1.0	1.0			
3	1470	1.0	1.0	1.0			
3	1474	1.0	1.0	1.0			
3	1561	1.0	1.0	1.0			
3	1570	1.0	1.0	1.0			
3	1574	1.0	1.0	1.0			

TABLE 2-5 (Continued)

3	1661	1.0	1.0	1.0		
3	1670	2.109	2.108	2.088		
3	1674	-7.17972	-2-7.17972	-2-7.17972	-2	
3	1961	844.54	844.54	844.54		
3	1970	2409.84	2409.84	2409.84		
3	1974	-161.9	-163.5	-183.1		
3	2160	0.0	0.0	69.0		
3	2163	45.0	0.0	69.0		
3	2166	55.0	0.0	69.0		
3	2169	65.0	0.0	69.0		
3	2172	0.0	0.0	138.0		
3	2175	0.0	0.0	145.0		
3	2178	60.0	0.0	145.0		
3	2181	0.0	0.0	175.0		
3	2184	0.0	0.0	200.0		
3	2187	0.0	0.0	217.0		
3	2190	0.0	0.0	230.0		
3	2193	80.0	0.0	75.0		
3	2196	0.0	0.0	-10.0		
3	2199	0.0	0.0	584.0		
3	2202	0.0	0.0	588.29		
3	2205	0.0	0.0	770.0		
3	2208	0.0	0.0	798.0		
3	2211	252.0	0.0	778.0		
3	2214	257.25	0.0	778.0		
3	2217	300.0	0.0	778.0		
3	2220	0.0	0.0	950.0		
3	2223	0.0	0.0	1600.0		
3	2226	0.0	0.0	1656.0		
3	2229	487.27	0.0	1656.0		
3	2232	487.70	0.0	1656.0		
3	2235	500.0	0.0	1656.0		
3	2238	0.0	0.0	2400.0		
3	2241	0.0	0.0	2410.0		
3	2244	0.0	0.0	2745.55		
3	2247	0.0	0.0	2745.80		
3	2250	0.0	0.0	2752.0		
3	2253	0.0	0.0	2760.0		
3	2256	1100.0	0.0	75.0		
3	2259	0.0	0.0	-1100.0		
5	3460	10.0	9.0	8.0	7.0	6.0
5	3465	5.0	4.0	3.2	2.5	1.8
5	3470	1.3	0.95	0.7	0.5	0.4
5	3475	0.3	0.2	0.1	0.09	0.08
5	3480	0.07	0.06	0.05	0.04	0.03
2	3485	0.02	0.01			
5	3490	.0407	.0091	.0091	.0210	.0217
5	3495	.0190	0.0	.016	.029	.058

TABLE 2-5 (Continued)

2	3500	.072		.022									
5	3510												
5	3515			8.688097307									
2	3520												
5	3530	.0407		.0091		.0091		.0210		.0217			
5	3535	.019		.6		.016		.029		.058			
2	3540	.072		.022									
1	3550	0.0407											
5	3551	1.6	-04	2.9	-01	7.78	-01	5.8	-01	3.5	-05		
2	3556	1.0	&01	9.58	-02								
1	3558	1.0											
5	3560	8.5		7.25		6.5		5.5		4.5			
5	3565	3.5		2.8		2.5		2.0		1.5			
3	3570	1.0		0.7		0.3							
4	4310	0.0		20.0		1.0	-06	1.0	-03				
4	4314	10.0		1.0		0.1		0.01					
5	4620	0.92058		-2.52297	-2	-1.31193	-4	0.		0.		C	BI
5	4625	-7.35248	-1	3.5555	-3	-2.92013	-5	0.		0.		C	BI
5	4630	-3.33736	-3	-2.40152	-3	1.4441	-5	0.		0.		C	BI
5	4635	-1.4929	-4	1.85572	-4	-9.78989	-7	0.		0.		C	BI
5	4645	2.02125	-1	4.96364	-2	-1.40544	-3	6.0468	-6	0.		C	BI
5	4650	3.27206	-1	-1.29057	-1	2.46613	-3	-1.2386	-5	0.		C	BI
5	4655	-6.57372	-1	8.7204	-2	-1.77728	-3	9.12486	-6	0.		C	BI
5	4670	2.48702		9.47202	-2	-1.65266	-3	6.16259	-6	0.		C	BI
5	4675	-2.80043	&1	-2.76004		1.58054	-2	3.6272	-6	0.		C	BI
5	4680	-1.29332	&2	4.63051	&1	-2.69301	-1	-1.28182	-4	0.		C	BI
5	4685	1.91579	&3	-2.44706	&2	1.589		-3.3677	-4	0.		C	BI
5	4720	.0663		.0663		.0663		.0663		.0663		C	BIV
5	4725	.0663		.0663		.0573		.0508		.049		C	BIV
5	4730	.0517		.0523		.0511		.0520		.0508		C	BIV
5	4735	.051		.050		.0493		.048		.048		C	BIV
5	4740	.0472		.0464		.0417		.0438		.0417		C	BIV
2	4745	.0412		.0464								C	BIV
50	4750	1.		1.		1.		1.		1.		RSPG	11
50	4755	1.		1.		1.		1.		1.		RSPG	12
30	4760	1.		1.		1.						RSPG	13
50	4780	8.5	-07	8.8	-07	9.2	-07	4.5	-07	1.05	-06	RSPG	21
50	4785	1.15	-06	1.23	-06	1.27	-06	1.37	-06	1.48	-06	RSPG	22
30	4790	1.61	-06	1.67	-06	1.66	-06					RSPG	23
50	4810	1.03	-06	1.05	-06	1.08	-06	1.16	-06	1.21	-06	RSPG	31
50	4815	1.31	-06	1.41	-06	1.45	-06	1.56	-06	1.69	-06	RSPG	32
30	4820	1.84	-06	1.94	-06	1.89	-06					RSPG	33
50	4840	3.91	-15	3.83	-15	3.77	-15	3.69	-15	3.62	-15	RSPG	41
50	4845	3.59	-15	3.62	-15	3.65	-15	3.70	-15	3.88	-15	RSPG	42
30	4850	4.22	-15	4.52	-15	5.45	-15					RSPG	43
50	4870	2.94	-15	2.96	-15	2.99	-15	3.05	-15	3.15	-15	RSPG	51
50	4875	3.31	-15	3.46	-15	3.58	-15	3.73	-15	3.95	-15	RSPG	52
30	4880	4.24	-15	4.54	-15	4.54	-15					RSPG	53

TABLE 2-5 (Continued)

5	5050	1.0		1.0		1.0		1.0		1.0	
5	5055	1.0		1.0		1.0		1.0		1.0	
5	5060	1.0		1.0		1.0		1.0		1.0	
5	5065	1.0		1.0		1.0		1.0		1.0	
5	5070	1.0		1.0		1.0		1.0		1.0	
2	5075	1.0		1.0							
5	5080	1.0		1.0		1.0		1.0		1.0	
5	5085	1.0		1.0		1.0		1.0		1.0	
1	5090	1.0									
5	5110	1.0		1.0		1.0		1.0		1.0	
5	5115	1.0		1.0		1.0		1.0		1.0	
5	5120	1.0		1.0		1.0		1.0		1.0	
3	5125	1.0		1.0		1.0					
5	5140	1.158	-4	1.101	-4	1.109	-4	1.068	-4	1.068	-4
5	5145	1.061	-4	1.040	-4	9.784	-5	9.033	-5	9.615	-5
5	5150	9.334	-5	8.502	-5	6.963	-5	4.358	-5	5.344	-5
5	5155	3.983	-5	3.481	-5	1.951	-5	1.781	-5	1.672	-5
5	5160	1.372	-5	1.141	-5	9.392	-6	7.206	-6	5.101	-6
2	5165	3.056	-6	1.178	-6						
5	5170	1.781	-5	1.688	-5	1.712	-5	1.619	-5	1.619	-5
5	5175	1.603	-5	1.489	-5	1.376	-5	1.179	-5	1.067	-5
5	5180	9.425	-6	7.719	-6	6.599	-6	5.748	-6	5.101	-6
5	5185	3.927	-6	3.716	-6	2.275	-6	2.133	-6	1.931	-6
5	5190	1.761	-6	1.554	-6	1.344	-6	1.137	-6	8.947	-7
2	5195	6.396	-7	3.441	-7						
1	5350	1.0									
5	5513	6.0		92.0		92.0		26.0		24.0	
5	5518	28.0		1.0		41.0		13.0		5.0	
2	5523	4.0		22.0							
3	5360	4.08932E&01		9.82485E&02		0.0					
3	5363	1.72450E&02		9.66991E&02		0.0					
3	5366	2.07006E&02		9.59660E&02		0.0					
3	5369	2.36312E&02		9.52337E&02		0.0					
3	5372	2.49593E&02		9.48676E&02		0.0					
3	5375	2.85467E&02		9.37698E&02		0.0					
3	5378	3.06841E&02		9.30380E&02		0.0					
3	5381	3.26655E&02		9.23063E&02		0.0					
3	5384	3.62608E&02		9.08430E&02		0.0					
3	5387	3.79097E&02		9.01114E&02		0.0					
3	5390	3.94761E&02		8.93798E&02		0.0					
10	5533	0.									
50	5534	3.50000E&00		9.50000E&00		1.40000E&01		1.80000E&01		2.20000E&01	
50	5539	2.60000E&01		3.00000E&01		3.35000E&01		3.65000E&01		3.90000E&01	
20	5544	4.10000E&01		4.27500E&01							
10	5546	4.35000E&01									
10	5584	0.									
50	5585	5.00000E-01		1.75000E&00		3.00000E&00		4.75000E&00		7.50000E&00	
50	5590	1.15000E&01		1.70000E&01		2.35000E&01		3.05000E&01		3.75000E&01	

TABLE 2-5 (Continued)

50	5595	4.45000E&01	5.15000E&01	5.85000E&01	6.55000E&01	7.25000E&01
50	5600	7.95000E&01	8.65000E&01	9.35000E&01	1.00500E&02	1.07500E&02
50	5605	1.14500E&02	1.21500E&02	1.27500E&02	1.31500E&02	1.34000E&02
20	5610	1.35650E&02	1.36730E&02			
10	5612	1.37160E&02				
10	5635	1.17635E&00				
50	5636	1.17419E&00	1.16040E&00	1.14022E&00	1.11432E&00	1.08085E&00
50	5641	1.03985E&00	9.92643E-01	9.49040E-01	9.14791E-01	8.93287E-01
20	5646	8.88781E-01	8.99383E-01			
10	5648	9.14665E-01				
10	5686	6.51712E-02				
50	5687	7.94648E-02	1.30459E-01	1.78508E-01	2.42148E-01	3.39037E-01
50	5692	4.72289E-01	6.42293E-01	8.21199E-01	9.87717E-01	1.12633E&00
50	5697	1.23737E&00	1.32077E&00	1.37619E&00	1.40323E&00	1.40168E&00
50	5702	1.37167E&00	1.31374E&00	1.22884E&00	1.11836E&00	9.84439E-01
50	5707	8.30944E-01	6.71155E-01	5.70514E-01	5.92375E-01	7.38165E-01
20	5712	9.86592E-01	1.30774E&00			
10	5714	1.61799E&00				
5	2460	1.508	6.823 -2	5.554 -3	2.707 -3	3.898 -4
3	2465	5.281 -3	5.390 -4	3.095 -2		
5	2486	1.403 -3	0.0	0.0	0.0	1.6606
1	2508	2.8095				
4	2526	6.297 -2	0.0	1.796	1.1032 -1	
1	2531	8.546 -1				
1	2540	3.061 -2				
3	2546	3.272 -2	0.0	2.2476		
1	2566	1.2645 -2				
1	2586	1.1839 -2				
1	2600	5.5 -2				
1	2606	2.41 -3				
1	2628	2.7				
1	2646	7.0 -2				
1	2666	8.8 -4				
10	5737	1.17411E&00				
50	5738	1.17191E&00	1.15794E&00	1.13751E&00	1.11138E&00	1.07774E&00
50	5743	1.03675E&00	9.89976E-01	9.47382E-01	9.15072E-01	8.96357E-01
20	5748	8.95759E-01	9.11517E-01			
10	5750	9.30294E-01				
10	5788	6.37057E-02				
50	5789	7.78718E-02	1.28642E-01	1.76484E-01	2.39895E-01	3.36500E-01
50	5794	4.69472E-01	6.39218E-01	8.17925E-01	9.84276E-01	1.12273E&00
50	5799	1.23360E&00	1.31685E&00	1.37216E&00	1.39914E&00	1.39759E&00
50	5804	1.36766E&00	1.30989E&00	1.22521E&00	1.11503E&00	9.81519E-01
50	5809	8.28723E-01	6.70949E-01	5.77256E-01	6.14374E-01	7.85148E-01
20	5814	1.06794E&00	1.43030E&00			
11	5816	1.77920E&00				
151	46	REGION NO.	2 RADIAL CORE EDGE REGION		P1	
1	32	1				

TABLE 2-5 (Continued)

2	50	4 14					2
4	52	12 12 14 14					2
21	75	12 29					
4	7	43.5	46.0	48.0	49.5	50.8	
2	1	1.0	0.38714				
50	1400	3.78941E-03	2.88111E-03	1.18102E-02	3.08338E-02	1.04411E-01	
50	1405	2.10084E-01	1.33641E-01	1.84014E-01	2.38973E-01	3.26125E-01	
30	1410	4.37918E-01	5.92243E-01	2.69925E-01			
10	5533	4.35000E&01					
50	5534	4.42500E&01	4.55000E&01	4.65000E&01	4.73750E&01	4.81250E&01	
50	5539	4.87500E&01	4.92500E&01	4.97500E&01	5.02000E&01	5.06000E&01	
10	5544	5.08000E&01					
10	5584	0.					
50	5585	5.00000E-01	1.75000E&00	3.00000E&00	4.75000E&00	7.50000E&00	
50	5590	1.15000E&01	1.70000E&01	2.35000E&01	3.05000E&01	3.75000E&01	
50	5595	4.45000E&01	5.15000E&01	5.85000E&01	6.55000E&01	7.25000E&01	
50	5600	7.95000E&01	8.65000E&01	9.35000E&01	1.00500E&02	1.07500E&02	
50	5605	1.14500E&02	1.21500E&02	1.27500E&02	1.31500E&02	1.34000E&02	
20	5610	1.35650E&02	1.36730E&02				
10	5612	1.37160E&02					
10	5635	7.69218E-01					
50	5636	7.81642E-01	8.19111E-01	8.68711E-01	9.29756E-01	1.00353E&00	
50	5641	1.08263E&00	1.16521E&00	1.26988E&00	1.38815E&00	1.52409E&00	
10	5646	1.61640E&00					
10	5686	6.01437E-02					
50	5687	7.41678E-02	1.25250E-01	1.74412E-01	2.40403E-01	3.41149E-01	
50	5692	4.79201E-01	6.53517E-01	8.34794E-01	1.00228E&00	1.14131E&00	
50	5697	1.25274E&00	1.33656E&00	1.39234E&00	1.41956E&00	1.41795E&00	
50	5702	1.38761E&00	1.32911E&00	1.24339E&00	1.13180E&00	9.96101E-01	
50	5707	8.38878E-01	6.69965E-01	5.44217E-01	5.12822E-01	5.67623E-01	
20	5712	6.86132E-01	8.54044E-01				
10	5714	1.01779E&00					
10	5737	7.46793E-01					
50	5738	7.61391E-01	8.03676E-01	8.58474E-01	9.25258E-01	1.00540E&00	
50	5743	1.09099E&00	1.18006E&00	1.29272E&00	1.41980E&00	1.56568E&00	
10	5748	1.66478E&00					
10	5788	5.90788E-02					
50	5789	7.29991E-02	1.23889E-01	1.72933E-01	2.38865E-01	3.39588E-01	
50	5794	4.77699E-01	6.52126E-01	8.33516E-01	1.00108E&00	1.14013E&00	
50	5799	1.25154E&00	1.33533E&00	1.39108E&00	1.41828E&00	1.41668E&00	
50	5804	1.38636E&00	1.32791E&00	1.24224E&00	1.13074E&00	9.95143E-01	
50	5809	8.38091E-01	6.69881E-01	5.46795E-01	5.21026E-01	5.84471E-01	
20	5814	7.14313E-01	8.95839E-01				
11	5816	1.07203E&00					
151	46	REGION NO.	3 RADIAL REFLECTOR REGION			P1	
1	31	2					
2	50	7 14					3
7	52	14 14 14 16 16 16 18					3

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TABLE 2-5 (Continued)

21	75	12 29					
5	7	50.8	52.0	54.0	56.0	58.0	R 3
3	12	60.0	62.0	63.5			R 3
2	1	1.0	0.				
50	1400	0.	0.	3.43749E-02	9.64007E-04	0.	
50	1405	1.26205E-02	0.	9.73689E-03	0.	0.	
30	1410	0.	1.74646E-03	0.			
10	5533	5.08000E&01					
50	5534	5.10500E&01	5.16500E&01	5.25000E&01	5.37500E&01	5.51900E&01	
50	5539	5.66900E&01	5.82500E&01	5.97500E&01	6.12500E&01	6.27500E&01	
10	5544	6.35000E&01					
10	5584	0.					
50	5585	5.00000E-01	1.75000E&00	3.00000E&00	4.75000E&00	7.50000E&00	
50	5590	1.15000E&01	1.70000E&01	2.35000E&01	3.05000E&01	3.75000E&01	
50	5595	4.45000E&01	5.15000E&01	5.85000E&01	6.55000E&01	7.25000E&01	
50	5600	7.95000E&01	8.65000E&01	9.35000E&01	1.00500E&02	1.07500E&02	
50	5605	1.14500E&02	1.21500E&02	1.27500E&02	1.31500E&02	1.34000E&02	
20	5610	1.35650E&02	1.36730E&02				
10	5612	1.37160E&02					
10	5635	7.62467E-01					
50	5636	8.20784E-01	9.65047E-01	1.11979E&00	1.26135E&00	1.33071E&00	
50	5641	1.29095E&00	1.15934E&00	9.57412E-01	7.02923E-01	4.02482E-01	
10	5646	3.06364E-01					
10	5686	4.43451E-02					
50	5687	5.78853E-02	1.12687E-01	1.64136E-01	2.33291E-01	3.38556E-01	
50	5692	4.81214E-01	6.59617E-01	8.43570E-01	1.01258E&00	1.15255E&00	
50	5697	1.26472E&00	1.34916E&00	1.40536E&00	1.43279E&00	1.43116E&00	
50	5702	1.40055E&00	1.34153E&00	1.25508E&00	1.14250E&00	1.00547E&00	
50	5707	8.45724E-01	6.71249E-01	5.30408E-01	4.62589E-01	4.46836E-01	
20	5712	4.54419E-01	4.69891E-01				
11	5714	4.81096E-01					
151	46	REGION NO. 4A RADIAL PRESSURE VESSEL REGION P1					
2	50	1 14					4A
1	52	18					4A
21	75	4 32					
2	7	63.5	66.04				R 4A
5	28	0.0	10.0	20.0	30.0	40.0	A1,2,3,4
5	33	50.0	60.0	70.0	80.0	90.0	A1,2,3,4
5	38	100.0	110.0	120.0	130.0	140.30	
2	1	1.0	0.				
50	1400	8.57492E-03	4.96391E-04	2.30521E-03	2.10969E-03	5.65985E-03	
50	1405	4.43303E-03	1.95834E-03	1.33418E-03	1.11629E-03	1.04117E-02	
30	1410	7.90781E-04	2.94292E-04	3.01566E-04			
10	5533	6.35000E&01					
20	5534	6.42500E&01	6.55200E&01				
10	5536	6.60400E&01					
10	5584	0.					
50	5585	5.00000E-01	1.75000E&00	3.00000E&00	4.75000E&00	7.50000E&00	

TABLE 2-5 (Continued)

50	5590	1.15000E&01	1.70000E&01	2.35000E&01	3.05000E&01	3.75000E&01	
50	5595	4.45000E&01	5.15000E&01	5.85000E&01	6.55000E&01	7.25000E&01	
50	5600	7.95000E&01	8.65000E&01	9.35000E&01	1.00500E&02	1.07500E&02	
50	5605	1.14500E&02	1.21500E&02	1.27500E&02	1.31500E&02	1.34000E&02	
50	5610	1.35650E&02	1.36730E&02	1.37580E&02	1.38500E&02	1.39350E&02	
1	5615	140.30					
10	5635	1.57333E&00					
20	5636	1.09908E&00	8.59868E-01				
10	5638	7.77738E-01					
10	5686	1.09592E-01					
50	5687	1.29366E-01	1.95849E-01	2.68646E-01	3.68290E-01	5.27098E-01	
50	5692	7.48490E-01	1.02410E&00	1.30825E&00	1.56934E&00	1.78575E&00	
50	5697	1.95923E&00	2.08993E&00	2.17691E&00	2.21941E&00	2.21684E&00	
50	5702	2.16945E&00	2.07805E&00	1.94417E&00	1.76993E&00	1.55767E&00	
50	5707	1.31035E&00	1.04183E&00	8.18124E-01	6.87165E-01	6.18104E-01	
50	5712	5.61336E-01	5.09526E-01	4.66233E-01	4.15600E-01	3.77724E-01	
11	5717	3.50104 -1					
151	46	REGION NO. 4B RADIAL PRESSURE VESSEL REGION P1					
2	50	1 7					4B
1	52	18					4B
21	75	4 49					
2	7	63.5	66.04				R 4B
5	28	140.30	145.0	155.0	165.0	175.0	A 4B
3	33	195.0	205.0	215.9			A 4B
2	1	1.0	0.				
50	1400	8.57492E-03	4.96391E-04	2.30521E-03	2.10969E-03	5.65985E-03	
50	1405	4.43303E-03	1.95834E-03	1.33418E-03	1.11629E-03	1.04117E-02	
30	1410	7.90781E-04	2.94292E-04	3.01566E-04			
10	5533	6.35000E&01					
20	5534	6.42500E&01	6.55200E&01				
10	5536	6.60400E&01					
50	5584	1.40300E&02	1.42400E&02	1.45900E&02	1.49900E&02	1.53420E&02	
50	5589	1.55005E&02	1.55135E&02	1.55265E&02	1.55395E&02	1.55525E&02	
50	5594	1.55655E&02	1.55785E&02	1.55945E&02	1.56240E&02	1.56740E&02	
50	5599	1.57590E&02	1.58690E&02	1.59990E&02	1.61490E&02	1.62990E&02	
50	5604	1.64490E&02	1.66240E&02	1.68240E&02	1.70240E&02	1.72240E&02	
50	5609	1.74240E&02	1.76240E&02	1.78240E&02	1.80240E&02	1.82240E&02	
50	5614	1.84240E&02	1.85990E&02	1.87490E&02	1.88740E&02	1.89740E&02	
50	5619	1.90590E&02	1.91290E&02	1.91840E&02	1.92140E&02	1.92340E&02	
50	5624	1.92540E&02	1.92740E&02	1.92890E&02	1.92990E&02	1.95520E&02	
30	5629	2.01000E&02	2.07000E&02	2.12950E&02			
10	5634	2.15900E&02					
50	5686	3.50104E-01	2.90578E-01	2.00018E-01	1.11193E-01	5.37184E-02	
50	5691	3.26822E-02	3.11182E-02	2.93873E-02	2.75044E-02	2.54854E-02	
50	5696	2.38802E-02	2.21157E-02	2.01318E-02	1.71852E-02	1.35559E-02	
50	5701	1.04774E-02	8.02487E-03	5.74968E-03	4.22404E-03	3.57458E-03	
50	5706	3.26294E-03	2.90605E-03	2.30569E-03	1.70168E-03	1.18488E-03	
50	5711	8.23674E-04	5.70436E-04	3.98089E-04	2.82405E-04	1.97120E-04	

TABLE 2-5 (Continued)

50	5716	1.42185E-04	1.02101E-04	7.77541E-05	6.56594E-05	5.59178E-05		
50	5721	4.97608E-05	4.73509E-05	4.53692E-05	4.39562F-05	4.30642E-05		
50	5726	4.22305E-05	4.12126E-05	4.04230E-05	3.99477E-05	3.32984E-05		
30	5731	2.99381E-05	3.05006E-05	2.42797E-05				
11	5736	2.06522E-05						
151	46	REGION NO.	5 AXIAL PLENUM REGION			P1		
2	50	7 2						5
7	52	2 4 6 8	10 12 14					5
21	75	34 5						
5	7	0.0	10.0	20.0	30.0	40.0	R	5
3	12	50.0	60.0	63.5			R	5
3	28	137.16	138.5	139.7			A	5
2	1	1.0	0.					
50	1400	0.	0.	0.	0.	0.		
50	1405	0.	0.	8.00756E-03	0.	0.		
30	1410	0.	0.	0.				
10	5533	0.						
50	5534	3.50000E&00	9.50000E&00	1.40000E&01	1.80000E&01	2.20000E&01		
50	5539	2.60000E&01	3.00000E&01	3.35000E&01	3.65000E&01	3.90000E&01		
50	5544	4.10000E&01	4.27500E&01	4.42500E&01	4.55000E&01	4.65000E&01		
50	5549	4.73750E&01	4.81250E&01	4.87500E&01	4.92500E&01	4.97500E&01		
50	5554	5.02000E&01	5.06000E&01	5.10500E&01	5.16500E&01	5.25000E&01		
50	5559	5.37500E&01	5.51900E&01	5.66900E&01	5.82500E&01	5.97500E&01		
20	5564	6.12500F&01	6.27500E&01					
10	5566	6.35000E&01						
10	5584	1.37160E&02						
30	5585	1.37580E&02	1.38500E&02	1.39350E&02				
10	5588	1.39700E&02						
10	5635	1.57785E&00						
50	5636	1.57503E&00	1.55704E&00	1.53032E&00	1.49532E&00	1.44868E&00		
50	5641	1.38897E&00	1.31504E&00	1.23925E&00	1.16540E&00	1.09954E&00		
50	5646	1.04469E&00	9.96595E-01	9.57025E-01	9.26504E-01	9.05570E-01		
50	5651	8.90535E-01	8.81639E-01	8.77452E-01	8.77439E-01	8.80886E-01		
50	5656	8.87008E-01	8.94247E-01	9.03334E-01	9.14924E-01	9.22789E-01		
50	5661	9.13965E-01	8.81094E-01	8.10504E-01	6.93901E-01	5.41997E-01		
20	5666	3.73386E-01	1.86906E-01					
10	5668	1.31714E-01						
10	5686	7.71813E-01						
30	5687	8.76655E-01	1.06448E&00	1.05590E&00				
11	5690	1.02474E&00						
151	46	REGION NO.	6 AXIAL PLENUM REGION			P1		
2	50	2 2						6
2	52	14 14						6
21	75	7 7						
3	7	55.88	60.0	63.5			R	6
3	28	139.7	145.0	154.94			A	6
2	1	1.0	0.					
50	1400	0.	0.	0.	0.	0.		

TABLE 2-5 (Continued)

```
 50      1405 0.           0.           2.72283E-03 0.           0.
 30      1410 0.           0.           0.
 10      5533 5.58800E&01
 50      5534 5.66900E&01 5.82500E&01 5.97500E&01 6.12500E&01 6.27500E&01
 10      5539 6.35000E&01
 10      5584 1.39700E&02
 50      5585 1.40300E&02 1.42400E&02 1.45900E&02 1.49900E&02 1.53420E&02
 10      5590 1.54940E&02
 10      5635 1.69091E&00
 50      5636 1.64585E&00 1.38641E&00 1.02414E&00 6.66063E-01 3.14112E-01
 10      5641 2.16772E-01
 10      5686 1.94562E&00
 50      5687 1.86006E&00 1.56647E&00 1.13489E&00 7.13016E-01 3.01609E-01
 11      5692 6.35821E-02
151        46 REGION NO.  7 AXIAL SUPPORT PLATE REGION      P1
  2        50  6  3                                                         7
  6        52  2  4  6  8 10 12
 21        75 29  7
  5         7 0.0          10.0         20.0         30.0         40.0          R  7
  2        12 50.0         55.88                                            R  7
  4        28 139.7        145.0        150.0        154.94                   A  7
  2         1 1.0          0.
 50      1400 1.75331E-02 1.02969E-03 4.78818E-03 4.42958E-03 1.17044E-02
 50      1405 9.18060E-03 4.08992E-03 7.77896E-03 2.42428E-03 2.13471E-02
 30      1410 1.68242E-03 6.19382E-04 6.19498E-04
 10      5533 0.
 50      5534 3.50000E&00 9.50000E&00 1.40000E&01 1.80000E&01 2.20000E&01
 50      5539 2.60000E&01 3.00000E&01 3.35000E&01 3.65000E&01 3.90000E&01
 50      5544 4.10000E&01 4.27500E&01 4.42500E&01 4.55000E&01 4.65000E&01
 50      5549 4.73750E&01 4.81250E&01 4.87500E&01 4.92500E&01 4.97500E&01
 50      5554 5.02000E&01 5.06000E&01 5.10500E&01 5.16500E&01 5.25000E&01
 20      5559 5.37500E&01 5.51900E&01
 10      5561 5.58800E&01
 10      5584 1.39700E&02
 50      5585 1.40300E&02 1.42400E&02 1.45900E&02 1.49900E&02 1.53420E&02
 10      5590 1.54940E&02
 10      5635 1.44850E&00
 50      5636 1.44570E&00 1.42787E&00 1.40158E&00 1.36742E&00 1.32239E&00
 50      5641 1.26538E&00 1.19562E&00 1.12470E&00 1.05592E&00 9.94441E-01
 50      5646 9.42695E-01 8.96468E-01 8.56650E-01 8.23799E-01 7.98232E-01
 50      5651 7.76585E-01 7.58824E-01 7.44581E-01 7.33701E-01 7.23254E-01
 50      5656 7.14191E-01 7.06389E-01 6.97894E-01 6.87104E-01 6.72632E-01
 20      5661 6.53882E-01 6.39046E-01
 10      5663 6.22169E-01
 10      5686 1.83579E&00
 50      5687 1.73407E&00 1.49947E&00 1.13770E&00 7.41033E-01 3.76900E-01
 11      5692 1.53117E-01
151        46 REGION NO.  8 AXIAL BATH SHIELD REGION        P1
```

TABLE 2-5 (Continued)

2	50	8 12						8
8	52	2 4 6 8 10 12 14 16						8
21	75	34 41						
5	7	0.0	10.0	20.0	30.0	40.0	R	8
4	12	50.0	55.0	60.0	63.5		R	8
5	28	154.94	155.5	158.0	162.0	166.0	A	8
5	33	170.0	174.0	178.0	182.0	182.0	A	8
3	38	186.0	190.0	193.04			A	8
2	1	1.0	0.					
50	1400	1.00346E-04	2.47759E-05	1.02079E-03	9.53349E-05	2.39458E-04		
50	1405	2.11365E-04	7.39501E-05	1.52885E-04	8.92423E-05	5.07486E-04		
30	1410	2.33734E-04	6.78779E-03	2.52332E-05				
10	5533	0.						
50	5534	3.50000E&00	9.50000E&00	1.40000E&01	1.80000E&01	2.20000E&01		
50	5539	2.60000E&01	3.00000E&01	3.35000E&01	3.65000E&01	3.90000E&01		
50	5544	4.10000E&01	4.27500E&01	4.42500E&01	4.55000E&01	4.65000E&01		
50	5549	4.73750E&01	4.81250E&01	4.87500E&01	4.92500E&01	4.97500E&01		
50	5554	5.02000E&01	5.06000E&01	5.10500E&01	5.16500E&01	5.25000E&01		
50	5559	5.37500E&01	5.51900E&01	5.66900E&01	5.82500E&01	5.97500E&01		
20	5564	6.12500E&01	6.27500E&01					
10	5566	6.35000E&01						
10	5584	1.54940E&02						
50	5585	1.55005E&02	1.55135E&02	1.55265E&02	1.55395E&02	1.55525E&02		
50	5590	1.55655E&02	1.55785E&02	1.55945E&02	1.56240E&02	1.56740E&02		
50	5595	1.57590E&02	1.58690E&02	1.59990E&02	1.61490E&02	1.62990E&02		
50	5600	1.64490E&02	1.66240E&02	1.68240E&02	1.70240E&02	1.72240E&02		
50	5605	1.74240E&02	1.76240E&02	1.78240E&02	1.80240E&02	1.82240E&02		
50	5610	1.84240E&02	1.85990E&02	1.87490E&02	1.88740E&02	1.89740E&02		
50	5615	1.90590E&02	1.91290E&02	1.91840E&02	1.92140E&02	1.92340E&02		
40	5620	1.92540E&02	1.92740E&02	1.92890E&02	1.92990E&02			
10	5624	1.93040E&02						
10	5635	1.88251E&00						
50	5636	1.87897E&00	1.85648E&00	1.82321E&00	1.77949E&00	1.72075E&00		
50	5641	1.64457E&00	1.54835E&00	1.44765E&00	1.34669E&00	1.25443E&00		
50	5646	1.17477E&00	1.10319E&00	1.04095E&00	9.90366E-01	9.48246E-01		
50	5651	9.11869E-01	8.80361E-01	8.54252E-01	8.34032E-01	8.13985E-01		
50	5656	7.95386E-01	7.78501E-01	7.60273E-01	7.34441E-01	6.99936E-01		
50	5661	6.43647E-01	5.47494E-01	3.86348E-01	2.51898E-01	1.90384E-01		
20	5666	1.25842E-01	7.83726E-02					
10	5668	1.31610E-01						
10	5686	9.32069E&01						
50	5687	8.62197E&01	3.71349E&01	2.11022E&01	1.39236E&01	1.01375E&01		
50	5692	7.87185E&00	6.47857E&00	5.38330E&00	4.21171E&00	3.10859E&00		
50	5697	2.19419E&00	1.50614E&00	1.06032E&00	7.28674E-01	5.17388E-01		
50	5702	3.74946E-01	2.64407E-01	1.77988E-01	1.21353E-01	8.34209E-02		
50	5707	5.76306E-02	3.99416E-02	2.77393E-02	1.92958E-02	1.34201E-02		
50	5712	9.33034E-03	6.75556E-03	5.12660E-03	4.05234E-03	3.34674E-03		
50	5717	2.85381E-03	2.52232E-03	2.34345E-03	2.30111E-03	2.33776E-03		

TABLE 2-5 (Continued)

40	5722	2.49615E-03	3.07863E-03	4.12893E-03	6.51415E-03			
11	5726	6.65559E-03						
151	46	REGION NO. 9 AXIAL DOME PLENUM REGION				P1		
2	50	7 4						9
7	52	2 4 6 8 10 12 14						9
21	75	34 6						
5	7	0.0	10.0	20.0	30.0	40.0	R	9
3	12	50.0	60.0	63.5			R	9
5	28	193.04	198.0	204.0	210.0	215.9	A	9
2	1	1.0	0.					
50	1400	0.	0.	0.	0.	0.		
50	1405	0.	0.	1.81855E-07	0.	0.		
30	1410	0.	0.	0.				
10	5533	0.						
50	5534	3.50000E&00	9.50000E&00	1.40000E&01	1.80000E&01	2.20000E&01		
50	5539	2.60000E&01	3.00000E&01	3.35000E&01	3.65000E&01	3.90000E&01		
50	5544	4.10000E&01	4.27500E&01	4.42500E&01	4.55000E&01	4.65000E&01		
50	5549	4.73750E&01	4.81250E&01	4.87500E&01	4.92500E&01	4.97500E&01		
50	5554	5.02000E&01	5.06000E&01	5.10500E&01	5.16500E&01	5.25000E&01		
50	5559	5.37500E&01	5.51900E&01	5.66900E&01	5.82500E&01	5.97500E&01		
20	5564	6.12500E&01	6.27500E&01					
10	5566	6.35000E&01						
10	5584	1.93040E&02						
40	5585	1.95520E&02	2.01000E&02	2.07000E&02	2.12950E&02			
10	5589	2.15900E&02						
10	5635	1.96572E&00						
50	5636	1.95931E&00	1.91849E&00	1.86121E&00	1.79157E&00	1.70611E&00		
50	5641	1.60574E&00	1.49156E&00	1.38192E&00	1.28041E&00	1.19173E&00		
50	5646	1.11778E&00	1.05135E&00	9.93031E-01	9.43646E-01	9.03535E-01		
50	5651	8.68084E-01	8.37397E-01	8.11651E-01	7.90919E-01	7.70080E-01		
50	5656	7.51240E-01	7.34417E-01	7.15416E-01	6.89946E-01	6.53614E-01		
50	5661	5.99682E-01	5.36916E-01	4.70655E-01	4.00753E-01	3.32098E-01		
20	5666	2.61146E-01	1.85666E-01					
10	5668	1.55962E-01						
10	5686	3.54431E-01						
40	5687	7.85373E-01	1.21977E&00	1.20350E&00	7.49981E-01			
11	5691	4.53204E-01						
151	46	REGION NO. 10 AXIAL PRESSURE VESSEL REGION				P1		
1	31	3						
2	50	7 2						10
7	52	2 4 6 8 10 12 14						10
21	75	36 4						
5	7	0.0	10.0	20.0	30.0	40.0	R	10
3	12	[illegible]	60.0	66.4			R	10
3	28	215.9	217.0	218.44			A	10
2	1	1.0	0.					
30	1400	4.19149E-08	4.01930E-09	1.93538E-08	2.28532E-08	4.19199E-08		
50	1405	3.42619E-08	1.88453E-08	3.02880E-08	2.57185E-08	6.45205E-08		

TABLE 2-5 (Continued)

30	1410	2.49050E-08	6.16882E-09	2.48045E-09		
10	5533	0.				
50	5534	3.50000E&00	9.50000E&00	1.40000E&01	1.80000E&01	2.20000E&01
50	5539	2.60000E&01	3.00000E&01	3.35000E&01	3.65000E&01	3.90000E&01
50	5544	4.10000E&01	4.27500E&01	4.42500E&01	4.55000E&01	4.65000E&01
50	5549	4.73750E&01	4.81250E&01	4.87500E&01	4.92500E&01	4.97500E&01
50	5554	5.02000E&01	5.06000E&01	5.10500E&01	5.16500E&01	5.25000E&01
50	5559	5.37500E&01	5.51900E&01	5.66900E&01	5.82500E&01	5.97500E&01
40	5564	6.12500E&01	6.27500E&01	6.42500E&01	6.55200E&01	
10	5568	6.60400E&01				
10	5584	2.15900E&02				
20	5585	2.16700E&02	2.17970E&02			
10	5587	2.18440E&02				
10	5635	1.90907E&00				
50	5636	1.90522E&00	1.88068E&00	1.80723E&00	1.72030E&00	1.63560E&00
50	5641	1.54594E&00	1.43899E&00	1.34613E&00	1.27038E&00	1.20327E&00
50	5646	1.13896E&00	1.07788E&00	1.03052E&00	9.94195E-01	9.68858E-01
50	5651	9.40465E-01	9.04511E-01	8.78416E-01	8.71588E-01	8.69175E-01
50	5656	8.61230E-01	8.32337E-01	7.92539E-01	7.64717E-01	7.42075E-01
50	5661	7.23916E-01	6.63804E-01	5.94387E-01	6.07213E-01	5.33745E-01
40	5666	4.32941E-01	4.38821E-01	3.80121E-01	2.68616E-01	
10	5670	2.31065E-01				
10	5686	1.20938E&00				
20	5687	1.07954E&00	8.64614E-01			
11	5689	7.96418E-01				

2.5 DESCRIPTION OF OUTPUT

The KAP-VI output data is dependent upon the input control words IOUT (1) and IOUT (2) entered at address 32 and 33, respectively.The control word, IOUT (1), controls the printout of the input data. The control word, IOUT (2) controls the print out of the output data and the control word ISUM controls the frequency of the print out of summary results.

2.5.1 Printed Output

The printout of the input data will be described first. If IOUT (1) is set at zero, no input data will be printed, except the program title. This is followed by the output data described in Section 5.2.

If IOUT (1) is set equal to one, the program title is printed, and is followed by a printout of the image of each input data card as used by the computer. Therefore, only columns 1 to 72 are printed. One exception must be noted: If the floating point data, input at address 2060, include the surface equation constant, D, for equation types 1, 2, or 3, the printed value in the card image is D and the computer squares D, D^2, for subsequent use in geometry calculations.

If IOUT (1) is set equal to two, the input data is printed out as described for IOUT (1) equal to one plus a set of labeled input data. This labeled printout is self explanatory (See the sample problem print Table 2-6). Included in the labeled print out are the normalized source distribution data. The labeled printout of the input is followed by the output described in Section 2.5.2.

The output printout is dependent upon the types of material attenuation functions that are requested in a particular problem. The output is also dependent upon the input control word ISUM (address 31), and the input control word IOUT (2) (address 33).

If IOUT (2) is set equal to zero, output is printed for each individual source region in the problem. If IOUT (2) is equal to one, the output for each source region is not printed out. Note: If the problem contains only one source region, IOUT (2) must be set equal to zero in order to obtain any answers.

The control word, (ISUM), controls the subtotal output over various source regions, and the total output over all source regions, as described in the input data instructions (Section 4.0).

If a gamma ray calculation is performed, the collided fluxes (contain the buildup factor) multiplied by each set of response functions is printed for the first detector point, for each gamma ray group, as well as the total. This is followed by the uncollided gamma ray data.

If an Albert-Welton calculation is performed, the output multiplied by the response functions is then printed.

At the end of the output data for each detector point, a comment is printed which tells the program user how many times the value of 20.0 mean free paths, for gamma rays, or 120.0 gm/cm^2, for neutrons, was exceeded for a source region.

A sample printout is included in Table 2-6.

2.5.2 Punched Card Output

The punched card output from the KAP VI code is dependent upon the input control word, ISUM. This punched output is obtained on cards in the FORTRAN format IP6E12.5 when the control word ISUM is set to 3 (i.e., when a total summary printout is obtained). The punched output consists of the gamma ray summary results by group of the first response function in the KAP VI problem. This optional punched card output is obtained by group and detector point for use in the SCAP code (See Section 3.0). The first response function should convert the KAP VI results into units of MeV/cm^2 - sec for use in SCAP. The data are obtained as NGG values of group data for the detector 1, NGG values of group data for detector 2, etc., for NDET detectors. The output is then NDET sets of cards with each set containing NGG values.

TABLE 2-6

SAMPLE PROBLEM COMPUTER PRINTOUT FOR THE KAP-VI CODE

MSFC SAMPLE PROBLEM - SOURCE DATA FROM NAGS
- GEOM. - 75 D. PROP. TANK
- MERIDIAN RING COS(A)=1.0 TO 0.9

11-0	1	13	27	12	12	1	33	34	3	5	1	12									
11-0	19	1	1	1	0	1	0	1	1	3	3	3									
4-0	30	1	-1	2	0																
3-0	35	3	2	3																	
3-0	40	2	3	3																	
20-0	100	6	2	2	2	6	6	6	6	6	6	2	2	2	6	2	2	2	3	3	3
13-0	120	3	6	6	6	6	6	6	6	3	3	3	3	3							
13-0	200	3	4	4	4	3	3	4	3	3	3	-4	4	3							
20-0	213	3	3	2	3	4	4	4	3	3	3	4	4	4	3	2	3	3	4	-2	-1
1-0	233	-2																			
13-0	300	1	1	2	3	4	6	4	5	7	3	12	12	12							
20-0	313	8	9	10	10	9	8	12	11	11	11	9	8	12	11	11	9	8	12	12	12
1-0	333	12																			
18-0	500	22	23	29	-0	-0	-0	22	29	23	30	-0	-0	22	30	23	32	-0	-0		
18-0	518	22	32	27	33	-0	-0	23	24	32	-0	-0	-0	24	25	31	-0	-0	-0		
18-0	536	24	31	25	32	-0	-0	25	26	32	-0	-0	-0	26	27	32	-0	-0	-0		
18-0	554	27	28	33	-0	-0	-0	28	2	5	21	-0	-0	22	33	28	21	-0	-0		
18-0	572	1	22	21	-0	-0	-0	2	5	3	-0	-0	-0	3	5	4	-0	-0	-0		
18-0	590	4	5	-0	-0	-0	-0	5	15	6	-0	-0	-0	5	16	8	15	-0	-0		
18-0	608	5	17	8	16	-0	-0	5	21	8	17	-0	-0	6	15	7	-0	-0	-0		
18-0	626	7	15	8	-0	-0	-0	8	18	9	-0	-0	-0	8	19	10	18	-0	-0		
18-0	644	8	20	10	19	-0	-0	8	21	10	20	-0	-0	9	18	10	-0	-0	-0		
18-0	662	10	11	-0	-0	-0	-0	10	12	11	-0	-0	-0	10	13	12	-0	-0	-0		
18-0	680	10	21	14	13	-0	-0	14	21	-0	-0	-0	-0	21	-0	-0	-0	-0	-0		
6-0	698	21	1	-0	-0	-0	-0														
18-0	1100	13	5	2	-0	-0	-0	13	1	5	3	-0	-0	13	2	5	4	-0	-0		
18-0	1118	13	3	10	12	-0	-0	1	6	4	-0	-0	-0	5	8	7	-0	-0	-0		
18-0	1136	5	6	8	4	-0	-0	6	9	4	-0	-0	-0	8	10	4	-0	-0	-0		
18-0	1154	9	11	12	-0	-0	-0	10	14	20	33	-0	-0	13	4	11	33	-0	-0		
18-0	1172	34	1	33	-0	-0	-0	11	19	15	-0	-0	-0	14	18	16	-0	-0	-0		
18-0	1190	15	17	-0	-0	-0	-0	16	18	21	-0	-0	-0	15	19	24	17	-0	-0		
18-0	1208	14	20	25	18	-0	-0	11	33	26	19	-0	-0	17	18	22	-0	-0	-0		
18-0	1226	21	18	23	-0	-0	-0	22	24	27	-0	-0	-0	18	25	29	23	-0	-0		
18-0	1244	19	26	30	24	-0	-0	20	33	31	25	-0	-0	23	24	28	-0	-0	-0		
18-0	1262	27	29	-0	-0	-0	-0	24	30	28	-0	-0	-0	25	31	29	-0	-0	-0		
18-0	1280	26	33	32	30	-0	-0	31	33	-0	-0	-0	-0	11	-0	-0	-0	-0	-0		
6-0	1298	33	34	-0	-0	-0	-0														
2-0	50	7	14																		
7-0	52	2	4	6	8	10	12	14													
2 1	75	14	29																		
2-0	1	1.00000E+00	8.30900E-01																		
5-0	7	0.	1.00000E+01	2.00000E+01	2.50000E+01	3.00000E+01															
3-0	12	3.50000E+01	4.00000E+01	4.35000E+01																	
5-0	28	0.	1.00000E+01	2.00000E+01	3.00000E+01	4.00000E+01															

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TABLE 2-6 (Continued)

5-0	33	5.00000E+01	6.00000E+01	7.00000E+01	8.00000E+01	9.00000E+01
5-0	38	1.00000E+02	1.10000E+02	1.20000E+02	1.30000E+02	1.37160E+02
2-0	49	0.	3.14159E+00			
5 0	1400	8.42206E-03	6.90293E-03	2.93810E-02	7.45449E-02	2.57404E-01
5 0	1405	4.73163E-01	2.99288E-01	4.11821E-01	5.38622E-01	7.26046E-01
3 0	1410	9.74204E-01	1.32113E+00	5.99359E-01		
5-0	1430	1.23500E+00	2.47000E+00	2.47000E+00	2.47000E+00	2.47000E+00
5-0	1435	2.47000E+00	2.47000E+00	1.48200E+00	1.97600E+00	1.48200E+00
5-0	1440	9.88800E-01	7.41000E-01	4.94000E-01	3.70500E-01	2.47000E-01
5-0	1445	2.47000E-01	2.47000E-01	1.35800E-01	2.47000E-02	2.47000E-02
5-0	1450	2.47000E-02	2.47000E-02	2.47000E-02	2.47000E-02	2.47000E-02
2-0	1455	2.47000E-02	1.23500E-02			
5-0	2060	-1.00000E+03	2.61540E+02	2.56460E+02	2.56040E+02	7.76970E+02
5-0	2065	8.98500E+02	1.28850E+03	1.65584E+03	2.18850E+03	2.40984E+03
5-0	2070	4.87260E+02	4.87680E+02	4.92760E+02	2.75600E+03	0.
5-0	2075	0.	0.	4.87260E+02	4.87680E+02	4.92760E+02
5-0	2080	1.00000E+03	0.	1.37160E+02	1.39700E+02	1.54940E+02
5-0	2085	1.93040E+02	2.15900E+02	2.18440E+02	4.35000E+01	5.08000E+01
3-0	2090	5.58800E+01	6.35000E+01	6.60400E+01		
3-0	1461	1.00000E+00	1.00000E+00	1.00000E+00		
3-0	1470	1.00000E+00	1.00000E+00	1.00000E+00		
3-0	1474	1.00000E+00	1.00000E+00	1.00000E+00		
3-0	1561	1.00000E+00	1.00000E+00	1.00000E+00		
3-0	1570	1.00000E+00	1.00000E+00	1.00000E+00		
3-0	1574	1.00000E+00	1.00000E+00	1.00000E+00		
3-0	1661	1.00000E+00	1.00000E+00	1.00000E+00		
3-0	1670	2.10900E+00	2.10800E+00	2.08800E+00		
3-0	1674	-7.17972E-02	-7.17972E-02	-7.17972E-02		
3-0	1961	8.44540E+02	8.44540E+02	8.44540E+02		
3-0	1970	2.40984E+03	2.40984E+03	2.40984E+03		
3-0	1974	-1.61900E+02	-1.63500E+02	-1.83100E+02		
3-0	2160	0.	0.	6.90000E+01		
3-0	2163	4.50000E+01	0.	6.90000E+01		
3-0	2166	5.50000E+01	0.	6.90000E+01		
3-0	2169	6.50000E+01	0.	6.90000E+01		
3-0	2172	0.	0.	1.38000E+02		
3-0	2175	0.	0.	1.45000E+02		
3-0	2178	6.00000E+01	0.	1.45000E+02		
3-0	2181	0.	0.	1.75000E+02		
3-0	2184	0.	0.	2.00000E+02		
3-0	2187	0.	0.	2.17000E+02		
3-0	2190	0.	0.	2.30000E+02		
3-0	2193	8.00000E+01	0.	7.50000E+01		
3-0	2196	0.	0.	-1.00000E+01		
3-0	2199	0.	0.	5.84000E+02		
3-0	2202	0.	0.	5.88290E+02		
3-0	2205	0.	0.	7.70000E+02		

TABLE 2-6 (Continued)

3-0	2208	0.	0.	7.98000E+02		
3-0	2211	2.52000E+02	0.	7.78000E+02		
3-0	2214	2.57250E+02	0.	7.78000E+02		
3-0	2217	3.00000E+02	0.	7.78000E+02		
3-0	2220	0.	0.	9.50000E+02		
3-0	2223	0.	0.	1.60000E+03		
3-0	2226	0.	0.	1.65600E+03		
3-0	2229	4.87270E+02	0.	1.65600E+03		
3-0	2232	4.87700E+02	0.	1.65600E+03		
3-0	2235	5.00000E+02	0.	1.65600E+03		
3-0	2238	0.	0.	2.40000E+03		
3-0	2241	0.	0.	2.41000E+03		
3-0	2244	0.	0.	2.74555E+03		
3-0	2247	0.	0.	2.74580E+03		
3-0	2250	0.	0.	2.75200E+03		
3-0	2253	0.	0.	2.76000E+03		
3-0	2256	1.10000E+03	0.	7.50000E+01		
3-0	2259	0.	0.	-1.10000E+03		
5-0	3460	1.00000E+01	9.00000E+00	8.00000E+00	7.00000E+00	6.00000E+00
5-0	3465	5.00000E+00	4.00000E+00	3.20000E+00	2.50000E+00	1.80000E+00
5-0	3470	1.30000E+00	9.50000E-01	7.00000E-01	5.00000E-01	4.00000E-01
5-0	3475	3.00000E-01	2.00000E-01	1.00000E-01	9.00000E-02	8.00000E-02
5-0	3480	7.00000E-02	6.00000E-02	5.00000E-02	4.00000E-02	3.00000E-02
2-0	3485	2.00000E-02	1.00000E-02			
5-0	3490	4.07000E-02	9.10000E-03	9.10000E-03	2.10000E-02	2.17000E-02
5-0	3495	1.90000E-02	0.	1.60000E-02	2.90000E-02	5.80000E-02
2-0	3500	7.20000E-02	2.20000E-02			
5-0	3510	-0.	-0.	-0.	-0.	-0.
5-0	3515	-0.	8.68810E+00	-0.	-0.	-0.
2-0	3520	-0.	-0.			
5-0	3530	4.07000E-02	9.10000E-03	9.10000E-03	2.10000E-02	2.17000E-02
5-0	3535	1.90000E-02	6.00000E-01	1.60000E-02	2.90000E-02	5.80000E-02
2-0	3540	7.20000E-02	2.20000E-02			
1-0	3550	4.07000E-02				
5-0	3551	1.60000E-04	2.90000E-01	7.78000E-01	5.80000E-01	3.50000E-05
2-0	3556	1.00000E+01	9.58000E-02			
1-0	3558	1.00000E+00				
5-0	3560	8.50000E+00	7.25000E+00	6.50000E+00	5.50000E+00	4.50000E+00
5-0	3565	3.50000E+00	2.80000E+00	2.50000E+00	2.00000E+00	1.50000E+00
3-0	3570	1.00000E+00	7.00000E-01	3.00000E-01		
4-0	4310	0.	2.00000E+01	1.00000E-06	1.00000E-03	
4-0	4314	1.00000E+01	1.00000E+00	1.00000E-01	1.00000E-02	
5-0	4620	9.20580E-01	-2.52297E-02	-1.31193E-04	0.	0.
5-0	4625	-7.35248E-01	3.55550E-03	-2.92013E-05	0.	0.
5-0	4630	-3.33736E-03	-2.40152E-03	1.44410E-05	0.	0.
5-0	4635	-1.49290E-04	1.85572E-04	-9.78989E-07	0.	0.
5-0	4645	2.02125E-01	4.96364E-02	-1.40544E-03	6.04680E-06	0.

TABLE 2-6 (Continued)

5-0	4650	3.27206E-01	-1.29057E-01	2.46613E-03	-1.23860E-05	0.
5-0	4655	-6.57372E-01	8.72040E-02	-1.77728E-03	9.12486E-06	0.
5-0	4670	2.48702E+00	9.47202E-02	-1.65266E-03	6.16259E-06	0.
5-0	4675	-2.80043E+01	-2.76004E+00	1.58054E-02	3.62720E-06	0.
5-0	4680	-1.29332E+02	4.63051E+01	-2.69301E-01	-1.28182E-04	0.
5-0	4685	1.91579E+03	-2.44706E+02	1.58900E+00	-3.36770E-04	0.
5-0	4720	6.63000E-02	6.63000E-02	6.63000E-02	6.63000E-02	6.63000E-02
5-0	4725	6.63000E-02	6.63000E-02	5.73000E-02	5.08000E-02	4.90000E-02
5-0	4730	5.17000E-02	5.23000E-02	5.11000E-02	5.20000E-02	5.08000E-02
5-0	4735	5.10000E-02	5.00000E-02	4.93000E-02	4.80000E-02	4.80000E-02
5-0	4740	4.72000E-02	4.64000E-02	4.17000E-02	4.38000E-02	4.17000E-02
2-0	4745	4.12000E-02	4.64000E-02			
5 0	4750	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00
5 0	4755	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00
3 0	4760	1.00000E+00	1.00000E+00	1.00000E+00		
5 0	4780	8.50000E-07	8.80000E-07	9.20000E-07	4.50000E-07	1.05000E-06
5 0	4785	1.15000E-06	1.23000E-06	1.27000E-06	1.37000E-06	1.48000E-06
3 0	4790	1.61000E-06	1.67000E-06	1.66000E-06		
5 0	4810	1.03000E-06	1.05000E-06	1.08000E-06	1.16000E-06	1.21000E-06
5 0	4815	1.31000E-06	1.41000E-06	1.45000E-06	1.56000E-06	1.69000E-06
3 0	4820	1.84000E-06	1.94000E-06	1.89000E-06		
5 0	4840	3.91000E-15	3.83000E-15	3.77000E-15	3.69000E-15	3.62000E-15
5 0	4845	3.59000E-15	3.62000E-15	3.65000E-15	3.70000E-15	3.88000E-15
3 0	4850	4.22000E-15	4.52000E-15	5.45000E-15		
5 0	4870	2.94000E-15	2.96000E-15	2.99000E-15	3.05000E-15	3.15000E-15
5 0	4875	3.31000E-15	3.46000E-15	3.58000E-15	3.73000E-15	3.95000E-15
3 0	4880	4.24000E-15	4.54000E-15	4.54000E-15		
5-0	5050	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00
5-0	5055	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00
5-0	5060	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00
5-0	5065	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00
5-0	5070	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00
2-0	5075	1.00000E+00	1.00000E+00			
5-0	5080	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00
5-0	5085	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00
1-0	5090	1.00000E+00				
5-0	5110	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00
5-0	5115	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00
5-0	5120	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00	1.00000E+00
3-0	5125	1.00000E+00	1.00000E+00	1.00000E+00		
5-0	5140	1.15800E-04	1.10100E-04	1.10900E-04	1.06800E-04	1.06800E-04
5-0	5145	1.06100E-04	1.04000E-04	9.78400E-05	9.03300E-05	9.61500E-05
5-0	5150	9.33400E-05	8.50200E-05	6.96300E-05	4.35800E-05	5.34400E-05
5-0	5155	3.98300E-05	3.48100E-05	1.95100E-05	1.78100E-05	1.67200E-05
5-0	5160	1.37200E-05	1.14100E-05	9.39200E-06	7.20600E-06	5.10100E-06
2-0	5165	3.05600E-06	1.17800E-06			
5-0	5170	1.78100E-05	1.68800E-05	1.71200E-05	1.61900E-05	1.61900E-05

TABLE 2-6 (Continued)

5-0	5175	1.60300E-05	1.48900E-05	1.37600E-05	1.17900E-05	1.06700E-05
5-0	5180	9.42500E-06	7.71900E-06	6.59900E-06	5.74800E-06	5.10100E-06
5-0	5185	3.92700E-06	3.71600E-06	2.27500E-06	2.13300E-06	1.93100E-06
5-0	5190	1.76100E-06	1.55400E-06	1.34400E-06	1.13700E-06	8.94700E-07
2-0	5195	6.39600E-07	3.44100E-07			
1-0	5350	1.00000E+00				
5-0	5513	6.00000E+00	9.20000E+01	9.20000E+01	2.60000E+01	2.40000E+01
5-0	5518	2.80000E+01	1.00000E+00	4.10000E+01	1.30000E+01	5.00000E+00
2-0	5523	4.00000E+00	2.20000E+01			
3-0	5360	4.08932E+01	9.82485E+02	0.		
3-0	5363	1.72450E+02	9.66991E+02	0.		
3-0	5366	2.07006E+02	9.59660E+02	0.		
3-0	5369	2.36312E+02	9.52337E+02	0.		
3-0	5372	2.49593E+02	9.48676E+02	0.		
3-0	5375	2.85467E+02	9.37698E+02	0.		
3-0	5378	3.06841E+02	9.30380E+02	0.		
3-0	5381	3.26655E+02	9.23063E+02	0.		
3-0	5384	3.62608E+02	9.08430E+02	0.		
3-0	5387	3.79097E+02	9.01114E+02	0.		
3-0	5390	3.94761E+02	8.93798E+02	0.		
1 0	5533	0.				
5 0	5534	3.50000E+00	9.50000E+00	1.40000E+01	1.80000E+01	2.20000E+01
5 0	5539	2.60000E+01	3.00000E+01	3.35000E+01	3.65000E+01	3.90000E+01
2 0	5544	4.10000E+01	4.27500E+01			
1 0	5546	4.35000E+01				
1 0	5584	0.				
5 0	5585	5.00000E-01	1.75000E+00	3.00000E+00	4.75000E+00	7.50000E+00
5 0	5590	1.15000E+01	1.70000E+01	2.35000E+01	3.05000E+01	3.75000E+01
5 0	5595	4.45000E+01	5.15000E+01	5.85000E+01	6.55000E+01	7.25000E+01
5 0	5600	7.95000E+01	8.65000E+01	9.35000E+01	1.00500E+02	1.07500E+02
5 0	5605	1.14500E+02	1.21500E+02	1.27500E+02	1.31500E+02	1.34000E+02
2 0	5610	1.35650E+02	1.36730E+02			
1 0	5612	1.37160E+02				
1 0	5635	1.17635E+00				
5 0	5636	1.17419E+00	1.16040E+00	1.14022E+00	1.11432E+00	1.08085E+00
5 0	5641	1.03985E+00	9.92643E-01	9.49040E-01	9.14791E-01	8.93287E-01
2 0	5646	8.88781E-01	8.99383E-01			
1 0	5648	9.14665E-01				
1 0	5686	6.51712E-02				
5 0	5687	7.94648E-02	1.30459E-01	1.78508E-01	2.42148E-01	3.39037E-01
5 0	5692	4.72289E-01	6.42293E-01	8.21199E-01	9.87717E-01	1.12633E+00
5 0	5697	1.23737E+00	1.32077E+00	1.37619E+00	1.40323E+00	1.40168E+00
5 0	5702	1.37167E+00	1.31374E+00	1.22884E+00	1.11836E+00	9.84439E-01
5 0	5707	8.30944E-01	6.71155E-01	5.70514E-01	5.92375E-01	7.38165E-01
2 0	5712	9.86592E-01	1.30774E+00			
1 0	5714	1.61799E+00				
5-0	2460	1.50800E+00	6.82300E-02	5.55400E-03	2.70700E-03	3.89800E-04

TABLE 2-6 (Continued)

3-0	2465	5.28100E-03	5.39000E-04	3.09500E-02		
5-0	2486	1.40300E-03	0.	0.	0.	1.66060E+00
1-0	2508	2.80950E+00				
4-0	2526	6.29700E-02	0.	1.79600E+00	1.10320E-01	
1-0	2531	8.54600E-01				
1-0	2540	3.06100E-02				
3-0	2546	3.27200E-02	0.	2.24760E+00		
1-0	2566	1.26450E-02				
1-0	2586	1.18390E-02				
1-0	2600	5.50000E-02				
1-0	2606	2.41000E-03				
1-0	2628	2.70000E+00				
1-0	2646	7.00000E-02				
1-0	2666	8.80000E-04				
1 0	5737	1.17411E+00				
5 0	5738	1.17191E+00	1.15794E+00	1.13751E+00	1.11138E+00	1.07774E+00
5 0	5743	1.03675E+00	9.89976E-01	9.47382E-01	9.15072E-01	8.96357E-01
2 0	5748	8.95759E-01	9.11517E-01			
1 0	5750	9.30294E-01				
1 0	5788	6.37057E-02				
5 0	5789	7.78718E-02	1.28642E-01	1.76484E-01	2.[illegible]895E-01	3.36500E-01
5 0	5794	4.69472E-01	6.39218E-01	8.17925E-01	9.84276E-01	1.12273E+00
5 0	5799	1.23360E+00	1.31685E+00	1.37216E+00	1.39914E+00	1.39759E+00
5 0	5804	1.36766E+00	1.30989E+00	1.22521E+00	1.11503E+00	9.81519E-01
5 0	5809	8.28723E-01	6.70949E-01	5.77256E-01	6.14374E-01	7.85148E-01
2 0	5814	1.06794E+00	1.43030E+00			
1 1	5816	1.77920E+00				

TABLE 2-6 (Continued)

GENERAL PROBLEM INPUT

NO. OF GAMMA GROUPS............	13
NO. OF NEUTRON GROUPS..........	27
NO. OF MATERIALS...............	12
NO. OF COMPOSITIONS............	12
NO. OF DETECTORS...............	1
NO. OF BOUNDARYS...............	33
NO. OF REGIONS.................	34
NO. OF RESPONSES(GAMMA)........	3
NO. OF RESPONSES(NEUTRON)......	5
NO. OF RESPONSES(ALBERT-WELTON)	1
NO. OF MATERIALS FROM LIBRARY..	12

CALCULATION OPTIONS

GAMMA RAY(0/NO,1/YES)..........	1
NEUTRON(0/NO,1/YES)............	
ALBERT-WELTON..............	1
MONOVARIANT MOMENTS........	0
BIVARIANT MOMENTS..........	1

PRINT OPTIONS

SOURCE REGION SUMMATION (0/NO,1/SUM,2/ST,3/GT).......	-1
INPUT PRINT(0/NO,1/CI,2/FULL).	2
OUTPUT PRINT (1/ST AND GT ONLY,2/ALL).....	0

SOURCE CALCULATION OPTIONS

SOURCE ZONE COMPOSITION.......	0
MOST PROBABLE ZONE............	1
SOURCE CALCULATION OPTION.....	1
RADIAL DISTRIBUTION...........	3
AXIAL OR POLAR DISTRIBUTION...	3
AZMUTHIAL DISTRIBUTION........	3

SOURCE INTERVAL DATA

NO. OF RADIAL.................	7
NO. OF AXIAL(OR POLAR)........	14

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TABLE 2-6 (Continued)

NO. OF AZMUTHIAL.............. 2 4 6 8 10 12 14

SOURCE AND DISTRIBUTION PARAMETERS

GAMMA RAY SOURCE(INPUT)..........	1.00000E+00
(NORMALIZED).....	2.42252E-06
NEUTRON SOURCE(INPUT)...........	8.30900E-01
(NORMAIZED)........	2.00821E-06
DISTRIBUTION PARAMETERS(XI(1))...	0.
(XI(2))...	0.
(ETA(1))..	0.
(ETA(2))..	0.

SOURCE INTERPOLATION DATA

NO. OF RADIAL VALUES..........	14
NO. OF AXIAL VALUES...........	29

SOURCE DISTRIBUTION DATA - RADIAL

PT. NO.	COORDINATE INPUT	COORDINATE MIDPOINT	GAMMA RAY INPUT	GAMMA RAY NORMALIZED	NEUTRON INPUT	NEUTRON NORMALIZED
1	0.	7.071E+00	1.176E+00	5.823E+01	1.174E+00	5.811E+01
2	1.000E+01	1.581E+01	1.159E+00	1.688E+02	1.156E+00	1.684E+02
3	2.000E+01	2.264E+01	1.099E+00	1.208E+02	1.095E+00	1.204E+02
4	2.500E+01	2.761E+01	1.051E+00	1.404E+02	1.046E+00	1.400E+02
5	3.000E+01	3.260E+01	9.926E-01	1.561E+02	9.900E-01	1.559E+02
6	3.500E+01	3.758E+01	9.308E-01	1.705E+02	9.299E-01	1.709E+02
7	4.000E+01	4.179E+01	8.888E-01	1.318E+02	8.936E-01	1.333E+02
8	4.350E+01		9.147E-01		9.303E-01	

SOURCE DISTRIBUTION DATA - AXIAL OR POLAR

PT. NO.	COORDINATE INPUT	COORDINATE MIDPOINT	GAMMA RAY INPUT	GAMMA RAY NORMALIZED	NEUTRON INPUT	NEUTRON NORMALIZED
1	0.	5.000E+00	6.517E-02	2.442E+00	6.371E-02	2.421E+00
2	1.000E+01	1.500E+01	4.233E-01	5.755E+00	4.205E-01	5.726E+00
3	2.000E+01	2.500E+01	7.278E-01	8.523E+00	7.246E-01	8.490E+00
4	3.000E+01	3.500E+01	9.767E-01	1.073E+01	9.733E-01	1.069E+01

5	4.000E+01	4.500E+01	1.169E+00	1.237E+01	1.165E+00	1.233E+01
6	5.000E+01	5.500E+01	1.305E+00	1.345E+01	1.301E+00	1.341E+01
7	6.000E+01	6.500E+01	1.384E+00	1.395E+01	1.380E+00	1.391E+01
8	7.000E+01	7.500E+01	1.406E+00	1.387E+01	1.401E+00	1.383E+01
9	8.000E+01	8.500E+01	1.368E+00	1.321E+01	1.364E+00	1.318E+01
10	9.000E+01	9.500E+01	1.274E+00	1.201E+01	1.271E+00	1.197E+01
11	1.000E+02	1.050E+02	1.127E+00	1.029E+01	1.124E+00	1.026E+01
12	1.100E+02	1.150E+02	9.303E-01	8.159E+00	9.275E-01	8.139E+00
13	1.200E+02	1.250E+02	7.016E-01	6.276E+00	7.004E-01	6.334E+00
14	1.300E+02	1.336E+02	5.537E-01	7.775E+00	5.664E-01	8.397E+00
15	1.372E+02		1.618E+00		1.779E+00	

SOURCE DISTRIBUTION DATA - AZMUTHIAL FOR RADIAL INTERVAL 1

PT.	COORDINATE		GAMMA RAY		NEUTRON	
NO.	INPUT	MIDPOINT	INPUT	NORMALIZED	INPUT	NORMALIZED
1	0.	7.854E-01	0.	3.805E-06	0.	3.154E-06
2	3.142E+00	2.356E+00	0.	3.805E-06	0.	3.154E-06
3	0.		0.		0.	

SOURCE DISTRIBUTION DATA - AZMUTHIAL FOR RADIAL INTERVAL 2

PT.	COORDINATE		GAMMA RAY		NEUTRON	
NO.	INPUT	MIDPOINT	INPUT	NORMALIZED	INPUT	NORMALIZED
1	0.	3.927E-01	0.	1.903E-06	0.	1.577E-06
2	0.	1.178E+00	0.	1.903E-06	0.	1.577E-06
3	0.	1.963E+00	0.	1.903E-06	0.	1.577E-06
4	0.	2.749E+00	0.	1.903E-06	0.	1.577E-06
5	0.		0.		0.	

SOURCE DISTRIBUTION DATA - AZMUTHIAL FOR RADIAL INTERVAL 3

PT.	COORDINATE		GAMMA RAY		NEUTRON	
NO.	INPUT	MIDPOINT	INPUT	NORMALIZED	INPUT	NORMALIZED
1	0.	2.618E-01	0.	1.268E-06	0.	1.051E-06
2	0.	7.854E-01	0.	1.268E-06	0.	1.051E-06
3	0.	1.309E+00	0.	1.268E-06	0.	1.051E-06
4	0.	1.833E+00	0.	1.268E-06	0.	1.051E-06

TABLE 2-6 (Continued)

5	0.	2.356E+00	0.	1.268E-06	0.	1.051E-06
6	0.	2.880E+00	0.	1.268E-06	0.	1.051E-06
7	0.		0.		0.	

SOURCE DISTRIBUTION DATA - AZMUTHIAL FOR RADIAL INTERVAL 4

PT. NO.	COORDINATE INPUT	COORDINATE MIDPOINT	GAMMA RAY INPUT	GAMMA RAY NORMALIZED	NEUTRON INPUT	NEUTRON NORMALIZED
1	0.	1.963E-01	0.	9.513E-07	0.	7.886E-07
2	0.	5.890E-01	0.	9.513E-07	0.	7.886E-07
3	0.	9.817E-01	0.	9.513E-07	0.	7.886E-07
4	0.	1.374E+00	0.	9.513E-07	0.	7.886E-07
5	0.	1.767E+00	0.	9.513E-07	0.	7.886E-07
6	0.	2.160E+00	0.	9.513E-07	0.	7.886E-07
7	0.	2.553E+00	0.	9.513E-07	0.	7.886E-07
8	0.	2.945E+00	0.	9.513E-07	0.	7.886E-07
9	0.		0.		0.	

SOURCE DISTRIBUTION DATA - AZMUTHIAL FOR RADIAL INTERVAL 5

PT. NO.	COORDINATE INPUT	COORDINATE MIDPOINT	GAMMA RAY INPUT	GAMMA RAY NORMALIZED	NEUTRON INPUT	NEUTRON NORMALIZED
1	0.	1.571E-01	0.	7.611E-07	0.	6.309E-07
2	0.	4.712E-01	0.	7.611E-07	0.	6.309E-07
3	0.	7.854E-01	0.	7.611E-07	0.	6.309E-07
4	0.	1.100E+00	0.	7.611E-07	0.	6.309E-07
5	0.	1.414E+00	0.	7.611E-07	0.	6.309E-07
6	0.	1.728E+00	0.	7.611E-07	0.	6.309E-07
7	0.	2.042E+00	0.	7.611E-07	0.	6.309E-07
8	0.	2.356E+00	0.	7.611E-07	0.	6.309E-07
9	0.	2.670E+00	0.	7.611E-07	0.	6.309E-07
10	0.	2.985E+00	0.	7.611E-07	0.	6.309E-07
11	0.		0.		0.	

SOURCE DISTRIBUTION DATA - AZMUTHIAL FOR RADIAL INTERVAL 6

PT. NO.	COORDINATE INPUT	COORDINATE MIDPOINT	GAMMA RAY INPUT	GAMMA RAY NORMALIZED	NEUTRON INPUT	NEUTRON NORMALIZED

TABLE 2-6 (Continued)

1	0.	1.309E-01	0.	6.342E-07	0.	5.257E-07
2	0.	3.927E-01	0.	6.342E-07	0.	5.257E-07
3	0.	6.545E-01	0.	6.342E-07	0.	5.257E-07
4	0.	9.163E-01	0.	6.342E-07	0.	5.257E-07
5	0.	1.178E+00	0.	6.342E-07	0.	5.257E-07
6	0.	1.440E+00	0.	6.342E-07	0.	5.257E-07
7	0.	1.702E+00	0.	6.342E-07	0.	5.257E-07
8	0.	1.963E+00	0.	6.342E-07	0.	5.257E-07
9	0.	2.225E+00	0.	6.342E-07	0.	5.257E-07
10	0.	2.487E+00	0.	6.342E-07	0.	5.257E-07
11	0.	2.749E+00	0.	6.342E-07	0.	5.257E-07
12	0.	3.011E+00	0.	6.342E-07	0.	5.257E-07
13	0.		0.		0.	

SOURCE DISTRIBUTION DATA - AZMUTHIAL FOR RADIAL INTERVAL 7

PT. NO.	COORDINATE INPUT	MIDPOINT	GAMMA RAY INPUT	NORMALIZED	NEUTRON INPUT	NORMALIZED
1	0.	1.122E-01	0.	5.436E-07	0.	4.506E-07
2	0.	3.366E-01	0.	5.436E-07	0.	4.506E-07
3	0.	5.610E-01	0.	5.436E-07	0.	4.506E-07
4	0.	7.854E-01	0.	5.436E-07	0.	4.506E-07
5	0.	1.010E+00	0.	5.436E-07	0.	4.506E-07
6	0.	1.234E+00	0.	5.436E-07	0.	4.506E-07
7	0.	1.459E+00	0.	5.436E-07	0.	4.506E-07
8	0.	1.683E+00	0.	5.436E-07	0.	4.506E-07
9	0.	1.907E+00	0.	5.436E-07	0.	4.506E-07
10	0.	2.132E+00	0.	5.436E-07	0.	4.506E-07
11	0.	2.356E+00	0.	5.436E-07	0.	4.506E-07
12	0.	2.581E+00	0.	5.436E-07	0.	4.506E-07
13	0.	2.805E+00	0.	5.436E-07	0.	4.506E-07
14	0.	3.029E+00	0.	5.436E-07	0.	4.506E-07
15	0.		0.		0.	

GAMMA RAY SPECTRAL DATA

GROUP NO.	ENERGY	SPECTRAL DATA
1	8.500E+00	8.422E-03
2	7.250E+00	6.903E-03
3	6.500E+00	2.938E-02

4	5.500E+00	7.454E-02
5	4.500E+00	2.574E-01
6	3.500E+00	4.732E-01
7	2.800E+00	2.993E-01
8	2.500E+00	4.118E-01
9	2.000E+00	5.386E-01
10	1.500E+00	7.260E-01
11	1.000E+00	9.742E-01
12	7.000E-01	1.321E+00
13	3.000E-01	5.994E-01

NEUTRON SPECTRAL DATA

GROUP NO.	ENERGY	SPECTRAL DATA
1	1.000E+01	1.235E+00
2	9.000E+00	2.470E+00
3	8.000E+00	2.470E+00
4	7.000E+00	2.470E+00
5	6.000E+00	2.470E+00
6	5.000E+00	2.470E+00
7	4.000E+00	2.470E+00
8	3.200E+00	1.482E+00
9	2.500E+00	1.976E+00
10	1.800E+00	1.482E+00
11	1.300E+00	9.888E-01
12	9.500E-01	7.410E-01
13	7.000E-01	4.940E-01
14	5.000E-01	3.705E-01
15	4.000E-01	2.470E-01
16	3.000E-01	2.470E-01
17	2.000E-01	2.470E-01
18	1.000E-01	1.358E-01
19	9.000E-02	2.470E-02
20	8.000E-02	2.470E-02
21	7.000E-02	2.470E-02
22	6.000E-02	2.470E-02
23	5.000E-02	2.470E-02
24	4.000E-02	2.470E-02
25	3.000E-02	2.470E-02
26	2.000E-02	2.470E-02
27	1.000E-02	1.235E-02

ZONE BOUNDARY SPECIFACTIONS

TABLE 2-6 (Continued)

ZONE	COMP.	BND.	ZONE	BND.	ZONE	BND.	ZONE	BND.	ZONE	BND.	ZONE	BND.	ZONE
1	1	-22	13	23	5	29	2						
2	1	-22	13	-29	1	23	5	30	3				
3	2	-22	13	-30	2	23	5	32	4				
4	3	-22	13	-32	3	27	10	33	12				
5	4	-23	1	24	6	32	4						
6	6	-24	5	25	8	31	7						
7	4	-24	5	-31	6	25	8	32	4				
8	5	-25	6	26	9	32	4						
9	7	-26	8	27	10	32	4						
10	3	-27	9	28	11	33	12						
11	12	-28	10	-2	14	5	20	21	33				
12	12	-22	13	-33	4	28	11	21	33				
13	12	-1	34	22	1	21	33						
14	8	2	11	5	19	-3	15						
15	9	3	14	5	18	-4	16						
16	10	4	15	5	17								
17	10	-5	16	15	18	6	21						
18	9	-5	15	16	19	8	24	-15	17				
19	8	-5	14	17	20	8	25	-16	18				
20	12	-5	11	21	33	8	26	-17	19				
21	11	-6	17	15	18	7	22						
22	11	-7	21	15	18	8	23						
23	11	-8	22	18	24	9	27						
24	9	-8	18	19	25	10	29	-18	23				
25	8	-8	19	20	26	10	30	-19	24				
26	12	-8	20	21	33	10	31	-20	25				
27	11	-9	23	18	24	10	28						
28	11	-10	27	11	29								
29	9	-10	24	12	30	-11	28						
30	8	-10	25	13	31	-12	29						
31	12	-10	26	21	33	14	32	-13	30				
32	12	-14	31	21	33								
33	12	-21	11										
34	12	21	33	1	34								

BOUNDARY EQUATION CONSTANTS

BND. NO.	AND TYPE	A0	X0	B0	Y0	C0	Z0	D0
1	6	0.	0.	0.	0.	0.	0.	-1.000E+03
2	2	1.000E+00	0.	1.000E+00	0.	1.000E+00	8.445E+02	6.840E+04
3	2	1.000E+00	0.	1.000E+00	0.	1.000E+00	8.445E+02	6.577E+04
4	2	1.000E+00	0.	1.000E+00	0.	1.000E+00	8.445E+02	6.556E+04

TABLE 2-6 (Continued)

5	6	0.	0.	0.	0.	0.	0.	7.770E+02
6	6	0.	0.	0.	0.	0.	0.	8.985E+02
7	6	0.	0.	0.	0.	0.	0.	1.288E+03
8	6	0.	0.	0.	0.	0.	0.	1.656E+03
9	6	0.	0.	0.	0.	0.	0.	2.188E+03
10	6	0.	0.	0.	0.	0.	0.	2.410E+03
11	2	1.000E+00	0.	1.000E+00	0.	2.109E+00	2.410E+03	2.374E+05
12	2	1.000E+00	0.	1.000E+00	0.	2.108E+00	2.410E+03	2.378E+05
13	2	1.000E+00	0.	1.000E+00	0.	2.088E+00	2.410E+03	2.429E+05
14	6	0.	0.	0.	0.	0.	0.	2.756E+03
15	2	1.000E+00	0.	1.000E+00	0.	-7.180E-02	-1.619E+02	0.
16	2	1.000E+00	0.	1.000E+00	0.	-7.180E-02	-1.635E+02	0.
17	2	1.000E+00	0.	1.000E+00	0.	-7.180E-02	-1.831E+02	0.
18	3	0.	0.	0.	0.	0.	0.	2.374E+05
19	3	0.	0.	0.	0.	0.	0.	2.378E+05
20	3	0.	0.	0.	0.	0.	0.	2.428E+05
21	3	0.	0.	0.	0.	0.	0.	1.000E+06
22	6	0.	0.	0.	0.	0.	0.	0.
23	6	0.	0.	0.	0.	0.	0.	1.372E+02
24	6	0.	0.	0.	0.	0.	0.	1.397E+02
25	6	0.	0.	0.	0.	0.	0.	1.549E+02
26	6	0.	0.	0.	0.	0.	0.	1.930E+02
27	6	0.	0.	0.	0.	0.	0.	2.159E+02
28	6	0.	0.	0.	0.	0.	0.	2.184E+02
29	3	0.	0.	0.	0.	0.	0.	1.892E+03
30	3	0.	0.	0.	0.	0.	0.	2.581E+03
31	3	0.	0.	0.	0.	0.	0.	3.123E+03
32	3	0.	0.	0.	0.	0.	0.	4.032E+03
33	3	0.	0.	0.	0.	0.	0.	4.361E+03

COMPOSITIONS BY MATERIAL

COMP.	MATERIAL NO.					
NO.	1	2	3	4	5	6
1	1.508E+00	6.823E-02	5.554E-03	2.707E-03	3.898E-04	5.281E-03
2	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.
5	3.061E-02	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.
8	5.500E-02	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.

COMPOSITIONS BY MATERIAL

COMP. NO.	MATERIAL NO. 7	8	9	10	11	12
1	5.390E-04	3.095E-02	0.	0.	0.	0.
2	1.403E-03	0.	0.	0.	1.661E+00	0.
3	0.	0.	2.809E+00	0.	0.	0.
4	6.297E-02	0.	1.796E+00	1.103E-01	0.	8.546E-01
5	3.272E-02	0.	2.248E+00	0.	0.	0.
6	1.265E-02	0.	0.	0.	0.	0.
7	1.184E-02	0.	0.	0.	0.	0.
8	2.410E-03	0.	0.	0.	0.	0.
9	0.	0.	2.700E+00	0.	0.	0.
10	7.000E-02	0.	0.	0.	0.	0.
11	8.800E-04	0.	0.	0.	0.	0.
12	0.	0.	0.	0.	0.	0.

COMPOSITION TOTAL DENSITY

1	1.622E+00
2	1.662E+00
3	2.809E+00
4	2.824E+00
5	2.311E+00
6	1.265E-02
7	1.184E-02
8	5.741E-02
9	2.700E+00
10	7.000E-02
11	8.800E-04
12	0.

NEUTRON CROSS SECTION DATA

MAT. NO.	ALBERT-WELTON REMOVAL	ETA	MOMENTS REMOVAL
1	4.070E-02	-0.	4.070E-02
2	9.100E-03	-0.	9.100E-03
3	9.100E-03	-0.	9.100E-03
4	2.100E-02	-0.	2.100E-02
5	2.170E-02	-0.	2.170E-02
6	1.900E-02	-0.	1.900E-02

TABLE 2-6 (Continued)

7	0.	8.688E+00	6.000E-01
8	1.600E-02	-0.	1.600E-02
9	2.900E-02	-0.	2.900E-02
10	5.800E-02	-0.	5.800E-02
11	7.200E-02	-0.	7.200E-02
12	2.200E-02	-0.	2.200E-02

ALBERT-WELTON COEFF.,ALPHA(1).... 1.600E-04
,ALPHA(2).... 2.900E-01
,ALPHA(3).... 7.780E-01
,ALPHA(4).... 5.800E-01
,ALPHA(5).... 3.500E-05
,ALPHA(6).... 1.000E+01
,ALPHA(7).... 9.580E-02

REFERENCE MATERIAL REMOVAL........ 4.070E-02

GAMMA RAY LINEAR ABSORPTION COEFF.

MATERIAL NO.

COMP. NO.	ENERGY	1	2	3	4	5	6
1	8.500E+00	2.050E-02	4.888E-02	4.888E-02	2.980E-02	2.924E-02	3.038E-02
2	7.250E+00	2.227E-02	4.730E-02	4.730E-02	3.012E-02	2.967E-02	3.059E-02
3	6.500E+00	2.360E-02	4.628E-02	4.628E-02	3.043E-02	3.007E-02	3.082E-02
4	5.500E+00	2.560E-02	4.492E-02	4.492E-02	3.110E-02	3.086E-02	3.136E-02
5	4.500E+00	2.840E-02	4.383E-02	4.383E-02	3.228E-02	3.220E-02	3.239E-02
6	3.500E+00	3.270E-02	4.373E-02	4.373E-02	3.455E-02	3.466E-02	3.447E-02
7	2.800E+00	3.720E-02	4.510E-02	4.510E-02	3.742E-02	3.769E-02	3.720E-02
8	2.500E+00	3.950E-02	4.624E-02	4.624E-02	3.918E-02	3.952E-02	3.889E-02
9	2.000E+00	4.440E-02	4.824E-02	4.824E-02	4.291E-02	4.338E-02	4.249E-02
10	1.500E+00	5.180E-02	5.628E-02	5.628E-02	4.905E-02	4.963E-02	4.853E-02
11	1.000E+00	6.360E-02	7.603E-02	7.603E-02	5.988E-02	6.062E-02	5.920E-02
12	7.000E-01	7.450E-02	1.103E-01	1.103E-01	7.159E-02	7.247E-02	7.082E-02
13	3.000E-01	1.060E-01	4.565E-01	4.565E-01	1.063E-01	1.063E-01	1.069E-01

GAMMA RAY LINEAR ABSORPTION COEFF.

MATERIAL NO.

COMP. NO.	ENERGY	7	8	9	10	11	12
1	8.500E+00	3.550E-02	3.441E-02	2.350E-02	1.930E-02	1.730E-02	2.870E-02

TABLE 2-6 (Continued)

2	7.250E+00	3.969E-02	3.401E-02	2.432E-02	2.120E-02	1.909E-02	2.925E-02
3	6.500E+00	4.260E-02	3.380E-02	2.550E-02	2.340E-02	2.030E-02	2.972E-02
4	5.500E+00	4.720E-02	3.364E-02	2.710E-02	2.580E-02	2.220E-02	3.065E-02
5	4.500E+00	5.350E-02	3.381E-02	3.000E-02	2.920E-02	2.470E-02	3.216E-02
6	3.500E+00	6.290E-02	3.485E-02	3.350E-02	3.150E-02	2.860E-02	3.482E-02
7	2.800E+00	7.250E-02	3.675E-02	3.750E-02	3.600E-02	3.270E-02	3.801E-02
8	2.500E+00	7.750E-02	3.805E-02	3.900E-02	3.830E-02	3.490E-02	3.991E-02
9	2.000E+00	8.760E-02	4.086E-02	4.320E-02	4.300E-02	3.940E-02	4.390E-02
10	1.500E+00	1.030E-01	4.643E-02	5.000E-02	5.030E-02	4.590E-02	5.027E-02
11	1.000E+00	1.260E-01	5.665E-02	6.140E-02	6.230E-02	5.650E-02	6.144E-02
12	7.000E-01	1.480E-01	6.869E-02	7.200E-02	7.230E-02	6.610E-02	7.347E-02
13	3.000E-01	2.120E-01	1.253E-01	1.030E-01	1.040E-01	9.450E-02	1.068E-01

GAMMA RAY BUILDUP COEFF.

GROUP NO.	ENERGY	B0	B1	B2	B3
1	8.500E+00	1.005E+00	3.616E-01	-6.490E-03	1.354E-04
2	7.250E+00	1.004E+00	3.984E-01	-5.643E-03	1.127E-04
3	6.500E+00	1.003E+00	4.263E-01	-4.850E-03	9.197E-05
4	5.500E+00	1.002E+00	4.730E-01	-3.185E-03	4.975E-05
5	4.500E+00	1.001E+00	5.357E-01	-1.795E-04	-2.266E-05
6	3.500E+00	9.990E-01	6.236E-01	5.938E-03	-1.581E-04
7	2.800E+00	9.974E-01	7.079E-01	1.478E-02	-3.317E-04
8	2.500E+00	9.966E-01	7.516E-01	2.104E-02	-4.414E-04
9	2.000E+00	9.954E-01	8.357E-01	3.831E-02	-6.961E-04
10	1.500E+00	9.948E-01	9.280E-01	7.471E-02	-1.043E-03
11	1.000E+00	9.968E-01	9.870E-01	1.714E-01	-9.766E-04
12	7.000E-01	1.001E+00	9.502E-01	3.279E-01	1.718E-03
13	3.000E-01	9.823E-01	1.435E+00	8.439E-01	5.976E-02

MONOVARIANT POLYNOMIAL MOMENTS DATA

GROUP NO.	ENERGY	A0	A1	A2	A3	A4
1	1.000E+01	0.	0.	0.	0.	0.
2	9.000E+00	0.	0.	0.	0.	0.
3	8.000E+00	0.	0.	0.	0.	0.
4	7.000E+00	0.	0.	0.	0.	0.
5	6.000E+00	0.	0.	0.	0.	0.
6	5.000E+00	0.	0.	0.	0.	0.
7	4.000E+00	0.	0.	0.	0.	0.
8	3.200E+00	0.	0.	0.	0.	0.
9	2.500E+00	0.	0.	0.	0.	0.
10	1.800E+00	0.	0.	0.	0.	0.
11	1.300E+00	0.	0.	0.	0.	0.

TABLE 2-6 (Continued)

12	9.500E-01	0.	0.	0.	0.	0.
13	7.000E-01	0.	0.	0.	0.	0.
14	5.000E-01	0.	0.	0.	0.	0.
15	4.000E-01	0.	0.	0.	0.	0.
16	3.000E-01	0.	0.	0.	0.	0.
17	2.000E-01	0.	0.	0.	0.	0.
18	1.000E-01	0.	0.	0.	0.	0.
19	9.000E-02	0.	0.	0.	0.	0.
20	8.000E-02	0.	0.	0.	0.	0.
21	7.000E-02	0.	0.	0.	0.	0.
22	6.000E-02	0.	0.	0.	0.	0.
23	5.000E-02	0.	0.	0.	0.	0.
24	4.000E-02	0.	0.	0.	0.	0.
25	3.000E-02	0.	0.	0.	0.	0.
26	2.000E-02	0.	0.	0.	0.	0.
27	1.000E-02	0.	0.	0.	0.	0.
1	1.000E+01	0.	0.	0.	0.	0.
2	9.000E+00	0.	0.	0.	0.	0.
3	8.000E+00	0.	0.	0.	0.	0.
4	7.000E+00	0.	0.	0.	0.	0.
5	6.000E+00	0.	0.	0.	0.	0.
6	5.000E+00	0.	0.	0.	0.	0.
7	4.000E+00	0.	0.	0.	0.	0.
8	3.200E+00	0.	0.	0.	0.	0.
9	2.500E+00	0.	0.	0.	0.	0.
10	1.800E+00	0.	0.	0.	0.	0.
11	1.300E+00	0.	0.	0.	0.	0.
12	9.500E-01	0.	0.	0.	0.	0.
13	7.000E-01	0.	0.	0.	0.	0.
14	5.000E-01	0.	0.	0.	0.	0.
15	4.000E-01	0.	0.	0.	0.	0.
16	3.000E-01	0.	0.	0.	0.	0.
17	2.000E-01	0.	0.	0.	0.	0.
18	1.000E-01	0.	0.	0.	0.	0.
19	9.000E-02	0.	0.	0.	0.	0.
20	8.000E-02	0.	0.	0.	0.	0.
21	7.000E-02	0.	0.	0.	0.	0.
22	6.000E-02	0.	0.	0.	0.	0.
23	5.000E-02	0.	0.	0.	0.	0.
24	4.000E-02	0.	0.	0.	0.	0.
25	3.000E-02	0.	0.	0.	0.	0.
26	2.000E-02	0.	0.	0.	0.	0.
27	1.000E-02	0.	0.	0.	0.	0.

BIVARIANT POLYNOMIAL MOMENTS DATA

GROUP	ENERGY RANGE LIMITS	C0	C1	C2	C3	C4

TABLE 2-6 (Continued)

NO.	UPPER	LOWER				
1	1.000E+01	1.000E+00	9.206E-01	-2.523E-02	-1.312E-04	
1	1.000E+01	1.000E+00	-7.352E-01	3.556E-03	-2.920E-05	
1	1.000E+01	1.000E+00	-3.337E-03	-2.402E-03	1.444E-05	
1	1.000E+01	1.000E+00	-1.493E-04	1.856E-04	-9.790E-07	
2	1.000E+00	1.000E-01	2.021E-01	4.964E-02	-1.405E-03	6.047E-06
2	1.000E+00	1.000E-01	3.272E-01	-1.291E-01	2.466E-03	-1.239E-05
2	1.000E+00	1.000E-01	-6.574E-01	8.720E-02	-1.777E-03	9.125E-06
3	1.000E-01	1.000E-02	2.487E+00	9.472E-02	-1.653E-03	6.163E-06
3	1.000E-01	1.000E-02	-2.800E+01	-2.760E+00	1.581E-02	3.627E-06
3	1.000E-01	1.000E-02	-1.293E+02	4.631E+01	-2.693E-01	-1.282E-04
3	1.000E-01	1.000E-02	1.916E+03	-2.447E+02	1.589E+00	-3.368E-04

MOMENTS DATA EXTRAPOLATION PARAMETERS

GROUP NO.	ENERGY	LAMBDA
1	1.000E+01	6.630E-02
2	9.000E+00	6.630E-02
3	8.000E+00	6.630E-02
4	7.000E+00	6.630E-02
5	6.000E+00	6.630E-02
6	5.000E+00	6.630E-02
7	4.000E+00	6.630E-02
8	3.200E+00	5.730E-02
9	2.500E+00	5.080E-02
10	1.800E+00	4.900E-02
11	1.300E+00	5.170E-02
12	9.500E-01	5.230E-02
13	7.000E-01	5.110E-02
14	5.000E-01	5.200E-02
15	4.000E-01	5.080E-02
16	3.000E-01	5.100E-02
17	2.000E-01	5.000E-02
18	1.000E-01	4.930E-02
19	9.000E-02	4.800E-02
20	8.000E-02	4.800E-02
21	7.000E-02	4.720E-02
22	6.000E-02	4.640E-02
23	5.000E-02	4.170E-02
24	4.000E-02	4.380E-02
25	3.000E-02	4.170E-02
26	2.000E-02	4.120E-02
27	1.000E-02	4.640E-02

GAMMA RAY RESPONSE DATA

TABLE 2-6 (Continued)

GROUP NO.	ENERGY	RESPONSE FUNCTION		
	1	2	3	
1	8.500E+00	1.000E+00	8.500E-07	1.030E-06
2	7.250E+00	1.000E+00	6.800E-07	1.050E-06
3	6.500E+00	1.000E+00	9.200E-07	1.080E-06
4	5.500E+00	1.000E+00	4.500E-07	1.160E-06
5	4.500E+00	1.000E+00	1.050E-06	1.210E-06
6	3.500E+00	1.000E+00	1.150E-06	1.310E-06
7	2.800E+00	1.000E+00	1.230E-06	1.410E-06
8	2.500E+00	1.000E+00	1.270E-06	1.450E-06
9	2.000E+00	1.000E+00	1.370E-06	1.560E-06
10	1.500E+00	1.000E+00	1.480E-06	1.690E-06
11	1.000E+00	1.000E+00	1.610E-06	1.840E-06
12	7.000E-01	1.000E+00	1.670E-06	1.940E-06
13	3.000E-01	1.000E+00	1.660E-06	1.890E-06

NEUTRON RESPONSE DATA

GROUP NO.	ENERGY	RESPONSE FUNCTION				
	1	2	3	4	5	
1	1.000E+01	1.000E+00	1.000E+00	1.000E+00	1.158E-04	1.781E-05
2	9.000E+00	1.000E+00	1.000E+00	1.000E+00	1.101E-04	1.688E-05
3	8.000E+00	1.000E+00	1.000E+00	1.000E+00	1.109E-04	1.712E-05
4	7.000E+00	1.000E+00	1.000E+00	1.000E+00	1.068E-04	1.619E-05
5	6.000E+00	1.000E+00	1.000E+00	1.000E+00	1.068E-04	1.619E-05
6	5.000E+00	1.000E+00	1.000E+00	1.000E+00	1.061E-04	1.603E-05
7	4.000E+00	1.000E+00	1.000E+00	1.000E+00	1.040E-04	1.489E-05
8	3.200E+00	1.000E+00	1.000E+00	1.000E+00	9.784E-05	1.376E-05
9	2.500E+00	1.000E+00	1.000E+00	1.000E+00	9.033E-05	1.179E-05
10	1.800E+00	1.000E+00	1.000E+00	1.000E+00	9.615E-05	1.067E-05
11	1.300E+00	1.000E+00	1.000E+00	1.000E+00	9.334E-05	9.425E-06
12	9.500E-01	1.000E+00	0.	1.000E+00	8.502E-05	7.719E-06
13	7.000E-01	1.000E+00	0.	1.000E+00	6.963E-05	6.599E-06
14	5.000E-01	1.000E+00	0.	1.000E+00	4.358E-05	5.748E-06
15	4.000E-01	1.000E+00	0.	1.000E+00	5.344E-05	5.101E-06
16	3.000E-01	1.000E+00	0.	1.000E+00	3.983E-05	3.927E-06
17	2.000E-01	1.000E+00	0.	1.000E+00	3.481E-05	3.716E-06
18	1.000E-01	1.000E+00	0.	1.000E+00	1.951E-05	2.275E-06
19	9.000E-02	1.000E+00	0.	0.	1.781E-05	2.133E-06
20	8.000E-02	1.000E+00	0.	0.	1.672E-05	1.931E-06
21	7.000E-02	1.000E+00	0.	0.	1.372E-05	1.761E-06
22	6.000E-02	1.000E+00	0.	0.	1.141E-05	1.554E-06
23	5.000E-02	1.000E+00	0.	0.	9.392E-06	1.344E-06
24	4.000E-02	1.000E+00	0.	0.	7.206E-06	1.137E-06

TABLE 2-6 (Continued)

25	3.000E-02	1.000E+00	0.	0.	5.101E-06	8.947E-07
26	2.000E-02	1.000E+00	0.	0.	3.056E-06	6.396E-07
27	1.000E-02	1.000E+00	0.	0.	1.178E-06	3.441E-07

ALBERT/WELTON RESPONSE DATA

GROUP NO.	ENERGY	RESPONSE FUNCTION 1
1	1.000E+00	1.000E+00

RECEIVER POINT COORDINATES

POINT NO.	COORDINATES R	Z	θ
1	4.089E+01	9.825E+02	0.

SOURCE POINT TRANSLATION COORDINATES

X...... 0.
Y...... 0.
Z...... 0.

LIBRARY MATERIAL ATOMIC NUMBERS

MAT. NO.	ATOMIC NUMBER
1	6.000E+00
2	9.200E+01
3	9.200E+01
4	2.600E+01
5	2.400E+01
6	2.800E+01
7	1.000E+00
8	4.100E+01
9	1.300E+01
10	5.000E+00
11	4.000E+00
12	2.200E+01

MISCELLANEOUS DATA

BOUNDARY SEARCH EPSILON..... 1.000E-06
BOUNDARY SEARCH PARAMETER... 1.000E-03
EMPIRICAL SOURCE SOLUTION
MEAN FREE PATHS............ 0.

TABLE 2-6 (Continued)

CALCULATED RESULTS FOR SOURCE REGION 1

REGION NO. 1 RADIAL CORE CENTER REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	3.170E-11	2.695E-17	3.265E-17
2	7.25	2.384E-11	2.098E-17	2.503E-17
3	6.50	9.104E-11	8.376E-17	9.832E-17
4	5.50	2.009E-10	9.039E-17	2.330E-16
5	4.50	5.403E-10	5.673E-16	6.538E-16
6	3.50	7.302E-10	8.398E-16	9.566E-16
7	2.80	3.272E-10	4.025E-16	4.614E-16
8	2.50	3.980E-10	5.055E-16	5.771E-16
9	2.00	3.735E-10	5.118E-16	5.827E-16
10	1.50	2.977E-10	4.407E-16	5.032E-16
11	1.00	1.807E-10	2.909E-16	3.324E-16
12	.70	1.333E-10	2.226E-16	2.586E-16
13	.30	1.008E-11	1.673E-17	1.905E-17
		---------	---------	---------
		3.339E-09	4.020E-15	4.734E-15

REGION NO. 1 RADIAL CORE CENTER REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

TABLE 2-6 (Continued)

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	1.451E-11	1.234E-17	1.495E-17
2	7.25	1.011E-11	8.893E-18	1.061E-17
3	6.50	3.614E-11	3.325E-17	3.904E-17
4	5.50	7.193E-11	3.237E-17	8.344E-17
5	4.50	1.667E-10	1.750E-16	2.017E-16
6	3.50	1.846E-10	2.123E-16	2.418E-16
7	2.80	6.742E-11	8.293E-17	9.507E-17
8	2.50	7.423E-11	9.427E-17	1.076E-16
9	2.00	5.546E-11	7.598E-17	8.652E-17
10	1.50	3.126E-11	4.627E-17	5.283E-17
11	1.00	1.031E-11	1.660E-17	1.897E-17
12	.70	3.878E-12	6.477E-18	7.524E-18
13	.30	4.233E-14	7.027E-20	8.001E-20
		---------	---------	---------
		7.266E-10	7.966E-16	9.602E-16

REGION NO. 1 RADIAL CORE CENTER REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	1.871E-13	1.871E-13	1.871E-13	2.167E-17	3.333E-18
2	9.00	4.453E-13	4.453E-13	4.453E-13	4.902E-17	7.516E-18
3	8.00	6.928E-13	6.928E-13	6.928E-13	7.683E-17	1.186E-17
4	7.00	1.341E-12	1.341E-12	1.341E-12	1.432E-16	2.171E-17
5	6.00	3.072E-12	3.072E-12	3.072E-12	3.281E-16	4.974E-17
6	5.00	7.922E-12	7.922E-12	7.922E-12	8.405E-16	1.270E-16
7	4.00	2.186E-11	2.186E-11	2.186E-11	2.274E-15	3.255E-16
8	3.20	3.133E-11	3.133E-11	3.133E-11	3.065E-15	4.311E-16
9	2.50	8.869E-11	8.869E-11	8.869E-11	8.011E-15	1.046E-15
10	1.80	1.336E-10	1.336E-10	1.336E-10	1.284E-14	1.425E-15
11	1.30	1.388E-10	1.388E-10	1.388E-10	1.296E-14	1.308E-15
12	.95	1.466E-10	0.	1.466E-10	1.246E-14	1.131E-15
13	.70	1.323E-10	0.	1.323E-10	9.211E-15	8.729E-16

TABLE 2-6 (Continued)

14	.50	1.213E-10	0.	1.213E-10	5.286E-15	6.973E-16
15	.40	8.966E-11	0.	8.966E-11	4.792E-15	4.574E-16
16	.30	9.782E-11	0.	9.782E-11	3.896E-15	3.841E-16
17	.20	1.071E-10	0.	1.071E-10	3.728E-15	3.980E-16
18	.10	6.400E-11	0.	6.400E-11	1.249E-15	1.456E-16
19	.09	1.385E-11	0.	0.	2.466E-16	2.954E-17
20	.08	1.533E-11	0.	0.	2.563E-16	2.960E-17
21	.07	1.729E-11	0.	0.	2.372E-16	3.045E-17
22	.06	2.045E-11	0.	0.	2.333E-16	3.178E-17
23	.05	2.745E-11	0.	0.	2.578E-16	3.689E-17
24	.04	3.840E-11	0.	0.	2.767E-16	4.366E-17
25	.03	6.568E-11	0.	0.	3.350E-16	5.876E-17
26	.02	1.329E-10	0.	0.	4.061E-16	8.499E-17
27	.01	1.576E-10	0.	0.	1.857E-16	5.424E-17
		---------	---------	---------	---------	---------
		1.676E-09	4.279E-10	1.187E-09	8.367E-14	9.243E-15

REGION NO. 1 RADIAL CORE CENTER REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

RADS(E)/HR

1	1.00	3.556E-15

		3.556E-15

FOR SOURCE REGION 1 AND DETECTOR POINT 1 THERE HAS BEEN 784 AND 672 PATH LENGTH CALCULATIONS IN EXCESS OF 20.0 MEAN FREE PATHS(GAMMA RAY) AND 120.0 GRAMS/CM**2(NEUTRON),RESPECTIVELY

TABLE 2-6 (Continued)

MSFC SAMPLE PROBLEM - SOURCE DATA FROM NAGS
- GEOM. - 75 D. PROP. TANK
- MERIDIAN RING COS(A)=1.0 TO 0.9

1-0	32	1				
2-0	50	4	14			
4-0	52	12	12	14	14	
2 1	75	12	29			
4-0	7	4.35000E+01	4.60000E+01	4.80000E+01	4.95000E+01	
2-0	1	1.00000E+00	3.87140E-01			
5 0	1400	3.78941E-03	2.88111E-03	1.18102E-02	3.08338E-02	1.04411E-01
5 0	1405	2.10084E-01	1.33641E-01	1.84014E-01	2.38973E-01	3.26125E-01
3 0	1410	4.37918E-01	5.92243E-01	2.69925E-01		
1 0	5533	4.35000E+01				
5 0	5534	4.42500E+01	4.55000E+01	4.65000E+01	4.73750E+01	4.81250E+01
5 0	5539	4.87500E+01	4.92500E+01	4.97500E+01	5.02000E+01	5.06000E+01
1 0	5544	5.08000E+01				
1 0	5584	0.				
5 0	5585	5.00000E-01	1.75000E+00	3.00000E+00	4.75000E+00	7.50000E+00
5 0	5590	1.15000E+01	1.70000E+01	2.35000E+01	3.05000E+01	3.75000E+01
5 0	5595	4.45000E+01	5.15000E+01	5.85000E+01	6.55000E+01	7.25000E+01
5 0	5600	7.95000E+01	8.65000E+01	9.35000E+01	1.00500E+02	1.07500E+02
5 0	5605	1.14500E+02	1.21500E+02	1.27500E+02	1.31500E+02	1.34000E+02
2 0	5610	1.35650E+02	1.36730E+02			
1 0	5612	1.37160E+02				
1 0	5635	7.69218E-01				
5 0	5636	7.81642E-01	8.19111E-01	8.68711E-01	9.29756E-01	1.00353E+00
5 0	5641	1.08263E+00	1.16521E+00	1.26988E+00	1.38815E+00	1.52409E+00
1 0	5646	1.61640E+00				
1 0	5686	6.01437E-02				
5 0	5687	7.41678E-02	1.25250E-01	1.74412E-01	2.40403E-01	3.41149E-01
5 0	5692	4.79201E-01	6.53517E-01	8.34794E-01	1.00228E+00	1.14131E+00
5 0	5697	1.25274E+00	1.33656E+00	1.39234E+00	1.41956E+00	1.41795E+00
5 0	5702	1.38761E+00	1.32911E+00	1.24339E+00	1.13180E+00	9.96101E-01
5 0	5707	8.38878E-01	6.69965E-01	5.44217E-01	5.12822E-01	5.67623E-01
2 0	5712	6.86132E-01	8.54044E-01			
1 0	5714	1.01779E+00				
1 0	5737	7.46793E-01				
5 0	5738	7.61391E-01	8.03676E-01	8.58474E-01	9.25258E-01	1.00540E+00
5 0	5743	1.09099E+00	1.18006E+00	1.29272E+00	1.41980E+00	1.56568E+00
1 0	5748	1.66478E+00				
1 0	5788	5.90788E-02				
5 0	5789	7.29991E-02	1.23689E-01	1.72933E-01	2.38865E-01	3.39588E-01
5 0	5794	4.77699E-01	6.52126E-01	8.33516E-01	1.00108E+00	1.14013E+00
5 0	5799	1.25154E+00	1.33533E+00	1.39108E+00	1.41828E+00	1.41668E+00
5 0	5804	1.38636E+00	1.32791E+00	1.24224E+00	1.13074E+00	9.95143E-01
5 0	5809	8.38091E-01	6.69881E-01	5.46795E-01	5.21026E-01	5.84471E-01
2 0	5814	7.14313E-01	8.95839E-01			

TABLE 2-6 (Continued)

```
1 1      5816  1.07203E+00

         CALCULATED RESULTS FOR SOURCE REGION    1

                        REGION NO.  2 RADIAL CORE EDGE REGION          P1


RECEIVER POINT  A=0.998
COORDINATES R......     4.08932E+01
            Z......     9.82485E+02
            PHI....     0.

          MEV/CM2-SEC RADS(C)/HR    REM/HR
```

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	1.337E-11	1.136E-17	1.377E-17
2	7.25	9.281E-12	8.167E-18	9.745E-18
3	6.50	3.401E-11	3.129E-17	3.673E-17
4	5.50	7.678E-11	3.455E-17	8.906E-17
5	4.50	2.009E-10	2.109E-16	2.430E-16
6	3.50	2.933E-10	3.373E-16	3.843E-16
7	2.80	1.304E-10	1.604E-16	1.839E-16
8	2.50	1.577E-10	2.002E-16	2.286E-16
9	2.00	1.449E-10	1.985E-16	2.260E-16
10	1.50	1.146E-10	1.696E-16	1.937E-16
11	1.00	6.761E-11	1.089E-16	1.244E-16
12	.70	4.860E-11	8.116E-17	9.428E-17
13	.30	3.458E-12	5.741E-18	6.536E-18
		---------	---------	---------
		1.295E-09	1.558E-15	1.834E-15

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                        REGION NO.  2 RADIAL CORE EDGE REGION          P1


RECEIVER POINT  A=0.998
COORDINATES R......     4.08932E+01
            Z......     9.82485E+02
            PHI....     0.
```

TABLE 2-6 (Continued)

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	6.042E-12	5.135E-18	6.223E-18
2	7.25	3.879E-12	3.413E-18	4.072E-18
3	6.50	1.330E-11	1.223E-17	1.436E-17
4	5.50	2.704E-11	1.217E-17	3.137E-17
5	4.50	6.084E-11	6.388E-17	7.361E-17
6	3.50	7.264E-11	8.353E-17	9.515E-17
7	2.80	2.627E-11	3.231E-17	3.704E-17
8	2.50	2.872E-11	3.647E-17	4.164E-17
9	2.00	2.098E-11	2.874E-17	3.273E-17
10	1.50	1.171E-11	1.733E-17	1.979E-17
11	1.00	3.749E-12	6.035E-18	6.897E-18
12	.70	1.372E-12	2.292E-18	2.662E-18
13	.30	1.419E-14	2.356E-20	2.683E-20
		---------	---------	---------
		2.765E-10	3.036E-16	3.656E-16

REGION NO. 2 RADIAL CORE EDGE REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	7.162E-14	7.162E-14	7.162E-14	8.293E-18	1.275E-18
2	9.00	1.696E-13	1.696E-13	1.696E-13	1.867E-17	2.862E-18
3	8.00	2.625E-13	2.625E-13	2.625E-13	2.911E-17	4.493E-18
4	7.00	5.055E-13	5.055E-13	5.055E-13	5.399E-17	8.184E-18
5	6.00	1.153E-12	1.153E-12	1.153E-12	1.231E-16	1.866E-17
6	5.00	2.960E-12	2.960E-12	2.960E-12	3.140E-16	4.744E-17
7	4.00	8.141E-12	8.141E-12	8.141E-12	8.466E-16	1.212E-16
8	3.20	1.178E-11	1.178E-11	1.178E-11	1.153E-15	1.621E-16
9	2.50	3.368E-11	3.368E-11	3.368E-11	3.042E-15	3.970E-16
10	1.80	5.088E-11	5.088E-11	5.088E-11	4.892E-15	5.429E-16
11	1.30	5.264E-11	5.264E-11	5.264E-11	4.914E-15	4.962E-16
12	.95	5.618E-11	0.	5.618E-11	4.776E-15	4.336E-16

13	.70	5.062E-11	0.	5.062E-11	3.524E-15	3.340E-16
14	.50	4.639E-11	0.	4.639E-11	2.022E-15	2.667E-16
15	.40	3.443E-11	0.	3.443E-11	1.840E-15	1.756E-16
16	.30	3.766E-11	0.	3.766E-11	1.500E-15	1.479E-16
17	.20	4.146E-11	0.	4.146E-11	1.443E-15	1.541E-16
18	.10	2.492E-11	0.	2.492E-11	4.863E-16	5.670E-17
19	.09	5.405E-12	0.	0.	9.627E-17	1.153E-17
20	.08	5.996E-12	0.	0.	1.003E-16	1.158E-17
21	.07	6.796E-12	0.	0.	9.324E-17	1.197E-17
22	.06	8.082E-12	0.	0.	9.222E-17	1.256E-17
23	.05	1.100E-11	0.	0.	1.033E-16	1.478E-17
24	.04	1.535E-11	0.	0.	1.106E-16	1.745E-17
25	.03	2.639E-11	0.	0.	1.346E-16	2.361E-17
26	.02	5.333E-11	0.	0.	1.630E-16	3.411E-17
27	.01	6.221E-11	0.	0.	7.328E-17	2.140E-17
		---------	---------	---------	---------	---------
		6.485E-10	1.622E-10	4.539E-10	3.195E-14	3.530E-15

REGION NO. 2 RADIAL CORE EDGE REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

RADS(E)/HR

1	1.00	1.409E-15

		1.409E-15

FOR SOURCE REGION 1 AND DETECTOR POINT 1 THERE HAS BEEN 728 AND 624 PATH LENGTH CALCULATIONS IN EXCESS OF 20.0 MEAN FREE PATHS(GAMMA RAY) AND 120.0 GRAMS/CM**2(NEUTRON),RESPECTIVELY

TABLE 2-6 (Continued)

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MSFC SAMPLE PROBLEM - SOURCE DATA FROM NAGS
                    - GEOM. - 75 D. PROP. TANK
                    - MERIDIAN RING COS(A)=1.0 TO 0.9
1-0     31  2
2-0     50   7  14
7-0     52  14  14  14  16  16  16  18
2 1     75  12  29
5-0      7  5.08000E+01  5.20000E+01  5.40000E+01  5.60000E+01  5.80000E+01
3-0     12  6.00000E+01  6.20000E+01  6.35000E+01
2-0      1  1.00000E+00  0.
5 0   1400  0.           0.           3.43749E-02  9.64007E-04  0.
5 0   1405  1.26205E-02  0.           9.73689E-03  0.           0.
3 0   1410  0.           1.74646E-03  0.
1 0   5533  5.08000E+01
5 0   5534  5.10500E+01  5.16500E+01  5.25000E+01  5.37500E+01  5.51900E+01
5 0   5539  5.66900E+01  5.82500E+01  5.97500E+01  6.12500E+01  6.27500E+01
1 0   5544  6.35000E+01
1 0   5584  0.
5 0   5585  5.00000E-01  1.75000E+00  3.00000E+00  4.75000E+00  7.50000E+00
5 0   5590  1.15000E+01  1.70000E+01  2.35000E+01  3.05000E+01  3.75000E+01
5 0   5595  4.45000E+01  5.15000E+01  5.85000E+01  6.55000E+01  7.25000E+01
5 0   5600  7.95000E+01  8.65000E+01  9.35000E+01  1.00500E+02  1.07500E+02
5 0   5605  1.14500E+02  1.21500E+02  1.27500E+02  1.31500E+02  1.34000E+02
2 0   5610  1.35650E+02  1.36730E+02
1 0   5612  1.37160E+02
1 0   5635  7.62467E-01
5 0   5636  8.20784E-01  9.65047E-01  1.11979E+00  1.26135E+00  1.33071E+00
5 0   5641  1.29095E+00  1.15934E+00  9.57412E-01  7.02923E-01  4.02482E-01
1 0   5646  3.06364E-01
1 0   5686  4.43451E-02
5 0   5687  5.78853E-02  1.12687E-01  1.64136E-01  2.33291E-01  3.38556E-01
5 0   5692  4.81214E-01  6.59617E-01  8.43570E-01  1.01258E+00  1.15255E+00
5 0   5697  1.26472E+00  1.34916E+00  1.40536E+00  1.43279E+00  1.43116E+00
5 0   5702  1.40055E+00  1.34153E+00  1.25508E+00  1.14250E+00  1.00547E+00
5 0   5707  8.45724E-01  6.71249E-01  5.30408E-01  4.62589E-01  4.46836E-01
2 0   5712  4.54419E-01  4.69891E-01
1 1   5714  4.81096E-01

        CALCULATED RESULTS FOR SOURCE REGION   1

              REGION NO.  3 RADIAL REFLECTOR REGION        P1
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TABLE 2-6 (Continued)

RECEIVER POINT A=0.998
COORDINATES R....... 4.08932E+01
Z....... 9.82485E+02
PHI..... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	0.	0.	0.
2	7.25	0.	0.	0.
3	6.50	8.865E-11	8.156E-17	9.574E-17
4	5.50	2.079E-12	9.355E-19	2.412E-18
5	4.50	0.	0.	0.
6	3.50	1.386E-11	1.594E-17	1.815E-17
7	2.80	0.	0.	0.
8	2.50	6.014E-12	7.638E-18	8.720E-18
9	2.00	0.	0.	0.
10	1.50	0.	0.	0.
11	1.00	0.	0.	0.
12	.70	7.771E-14	1.298E-19	1.508E-19
13	.30	0.	0.	0.
		1.107E-10	1.062E-16	1.252E-16

REGION NO. 3 RADIAL REFLECTOR REGION P1

RECEIVER POINT A=0.998
COORDINATES R....... 4.08932E+01
Z....... 9.82485E+02
PHI..... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	0.	0.	0.
2	7.25	0.	0.	0.
3	6.50	3.322E-11	3.057E-17	3.588E-17
4	5.50	6.971E-13	3.137E-19	8.087E-19
5	4.50	0.	0.	0.
6	3.50	3.213E-12	3.695E-18	4.209E-18
7	2.80	0.	0.	0.

TABLE 2-6 (Continued)

8	2.50	1.013E-12	1.287E-18	1.470E-18
9	2.00	0.	0.	0.
10	1.50	0.	0.	0.
11	1.00	0.	0.	0.
12	.70	1.981E-15	3.309E-21	3.844E-21
13	.30	0.	0.	0.
		---------	---------	---------
		3.815E-11	3.586E-17	4.237E-17

REGION NO. 3 RADIAL REFLECTOR REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	3.761E-14	3.761E-14	3.761E-14	4.356E-18	6.699E-19
2	9.00	8.829E-14	8.829E-14	8.829E-14	9.721E-18	1.490E-18
3	8.00	1.355E-13	1.355E-13	1.355E-13	1.502E-17	2.319E-18
4	7.00	2.586E-13	2.586E-13	2.586E-13	2.762E-17	4.187E-18
5	6.00	5.847E-13	5.847E-13	5.847E-13	6.245E-17	9.466E-18
6	5.00	1.490E-12	1.490E-12	1.490E-12	1.581E-16	2.389E-17
7	4.00	4.076E-12	4.076E-12	4.076E-12	4.239E-16	6.069E-17
8	3.20	6.194E-12	6.194E-12	6.194E-12	6.060E-16	8.522E-17
9	2.50	1.851E-11	1.851E-11	1.851E-11	1.672E-15	2.182E-16
10	1.80	2.837E-11	2.837E-11	2.837E-11	2.728E-15	3.027E-16
11	1.30	2.876E-11	2.876E-11	2.876E-11	2.684E-15	2.711E-16
12	.95	3.113E-11	0.	3.113E-11	2.647E-15	2.403E-16
13	.70	2.814E-11	0.	2.814E-11	1.960E-15	1.857E-16
14	.50	2.566E-11	0.	2.566E-11	1.118E-15	1.475E-16
15	.40	1.928E-11	0.	1.928E-11	1.030E-15	9.836E-17
16	.30	2.115E-11	0.	2.115E-11	8.424E-16	8.305E-17
17	.20	2.361E-11	0.	2.361E-11	8.219E-16	8.774E-17
18	.10	1.438E-11	0.	1.438E-11	2.806E-16	3.272E-17
19	.09	3.151E-12	0.	0.	5.612E-17	6.721E-18
20	.08	3.507E-12	0.	0.	5.864E-17	6.772E-18
21	.07	4.026E-12	0.	0.	5.524E-17	7.090E-18
22	.06	4.854E-12	0.	0.	5.539E-17	7.544E-18
23	.05	6.964E-12	0.	0.	6.541E-17	9.360E-18

TABLE 2-6 (Continued)

24	.04	9.548E-12	0.	0.	6.880E-17	1.086E-17
25	.03	1.679E-11	0.	0.	8.566E-17	1.502E-17
26	.02	3.401E-11	0.	0.	1.039E-16	2.175E-17
27	.01	3.730E-11	0.	0.	4.393E-17	1.283E-17
		---------	---------	---------	---------	---------
		3.720E-10	8.850E-11	2.519E-10	1.768E-14	1.953E-15

REGION NO. 3 RADIAL REFLECTOR REGION · P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

RADS(E)/HR

1 1.00 8.512E-16

8.512E-16

FOR SOURCE REGION 1 AND DETECTOR POINT 1 THERE HAS BEEN 1369 AND 1470 PATH LENGTH CALCULATIONS IN EXCESS OF 20.0 MEAN FREE PATHS(GAMMA RAY) AND 120.0 GRAMS/CM**2(NEUTRON),RESPECTIVELY

INTERMEDIATE SUMMARY RESULTS OVER A SUBSET OF SOURCE REGIONS

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

MEV/CM2-SEC RADS(C)/HR REM/HR

1	8.50	4.507E-11	3.831E-17	4.642E-17
2	7.25	3.312E-11	2.915E-17	3.478E-17
3	6.50	2.137E-10	1.966E-16	2.308E-16
4	5.50	2.797E-10	1.259E-16	3.245E-16
5	4.50	7.412E-10	7.782E-16	8.968E-16
6	3.50	1.037E-09	1.193E-15	1.359E-15
7	2.80	4.576E-10	5.629E-16	6.452E-16
8	2.50	5.617E-10	7.133E-16	8.144E-16
9	2.00	5.184E-10	7.103E-16	8.088E-16
10	1.50	4.123E-10	6.103E-16	6.968E-16
11	1.00	2.483E-10	3.997E-16	4.568E-16
12	.70	1.820E-10	3.039E-16	3.531E-16
13	.30	1.354E-11	2.248E-17	2.559E-17
		---------	---------	---------
		4.744E-09	5.684E-15	6.693E-15

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R....... 4.08932E+01
Z....... 9.82485E+02
PHI..... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	2.055E-11	1.747E-17	2.117E-17
2	7.25	1.398E-11	1.231E-17	1.468E-17
3	6.50	8.266E-11	7.605E-17	8.928E-17
4	5.50	9.967E-11	4.485E-17	1.156E-16
5	4.50	2.275E-10	2.389E-16	2.753E-16
6	3.50	2.605E-10	2.995E-16	3.412E-16
7	2.80	9.369E-11	1.152E-16	1.321E-16
8	2.50	1.040E-10	1.320E-16	1.507E-16
9	2.00	7.644E-11	1.047E-16	1.192E-16
10	1.50	4.297E-11	6.360E-17	7.262E-17
11	1.00	1.406E-11	2.264E-17	2.587E-17
12	.70	5.252E-12	8.771E-18	1.019E-17
13	.30	5.653E-14	9.383E-20	1.068E-19
		---------	---------	---------
		1.041E-09	1.136E-15	1.368E-15

TABLE 2-6 (Continued)

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI..... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	2.964E-13	2.964E-13	2.964E-13	3.432E-17	5.278E-18
2	9.00	7.031E-13	7.031E-13	7.031E-13	7.741E-17	1.187E-17
3	8.00	1.091E-12	1.091E-12	1.091E-12	1.210E-16	1.867E-17
4	7.00	2.105E-12	2.105E-12	2.105E-12	2.248E-16	3.408E-17
5	6.00	4.810E-12	4.810E-12	4.810E-12	5.137E-16	7.787E-17
6	5.00	1.237E-11	1.237E-11	1.237E-11	1.313E-15	1.983E-16
7	4.00	3.408E-11	3.408E-11	3.408E-11	3.544E-15	5.074E-16
8	3.20	4.931E-11	4.931E-11	4.931E-11	4.824E-15	6.784E-16
9	2.50	1.409E-10	1.409E-10	1.409E-10	1.273E-14	1.661E-15
10	1.80	2.128E-10	2.128E-10	2.128E-10	2.046E-14	2.271E-15
11	1.30	2.202E-10	2.202E-10	2.202E-10	2.055E-14	2.076E-15
12	.95	2.339E-10	0.	2.339E-10	1.988E-14	1.805E-15
13	.70	2.110E-10	0.	2.110E-10	1.469E-14	1.393E-15
14	.50	1.934E-10	0.	1.934E-10	8.427E-15	1.111E-15
15	.40	1.434E-10	0.	1.434E-10	7.662E-15	7.314E-16
16	.30	1.566E-10	0.	1.566E-10	6.238E-15	6.151E-16
17	.20	1.722E-10	0.	1.722E-10	5.993E-15	6.398E-16
18	.10	1.033E-10	0.	1.033E-10	2.015E-15	2.350E-16
19	.09	2.240E-11	0.	0.	3.990E-16	4.779E-17
20	.08	2.483E-11	0.	0.	4.152E-16	4.795E-17
21	.07	2.811E-11	0.	0.	3.857E-16	4.951E-17
22	.06	3.339E-11	0.	0.	3.809E-16	5.188E-17
23	.05	4.541E-11	0.	0.	4.265E-16	6.103E-17
24	.04	6.330E-11	0.	0.	4.561E-16	7.197E-17
25	.03	1.089E-10	0.	0.	5.553E-16	9.740E-17
26	.02	2.202E-10	0.	0.	6.730E-16	1.409E-16
27	.01	2.571E-10	0.	0.	3.029E-16	8.848E-17
		---------	---------	---------	---------	---------
		2.696E-09	6.787E-10	1.892E-09	1.333E-13	1.473E-14

EXTRA CORE REGIONS - TOTAL

TABLE 2-6 (Continued)

```
RECEIVER POINT  A=0.998
COORDINATES R.......     4.08932E+01
            Z.......     9.82485E+02
            PHI.....     0.

            RADS(E)/HR

1  1.00   5.816E-15
          ---------
          5.816E-15
```

TABLE 2-6 (Continued)

MSFC SAMPLE PROBLEM - SOURCE DATA FROM NAGS
- GEOM. - 75 D. PROP. TANK
- MERIDIAN RING COS(A)=1.0 TO 0.9

2-0	50	1 14				
1-0	52	18				
2 1	75	4 32				
2-0	7	6.35000E+01	6.60400E+01			
5-0	28	0.	1.00000E+01	2.00000E+01	3.00000E+01	4.00000E+01
5-0	33	5.00000E+01	6.00000E+01	7.00000E+01	8.00000E+01	9.00000E+01
5-0	38	1.00000E+02	1.10000E+02	1.20000E+02	1.30000E+02	1.40300E+02
2-0	1	1.00000E+00	0.			
5 0	1400	8.57492E-03	4.96391E-04	2.30521E-03	2.10969E-03	5.65985E-03
5 0	1405	4.43303E-03	1.95834E-03	1.33418E-03	1.11629E-03	1.04117E-02
3 0	1410	7.90781E-04	2.94292E-04	3.01566E-04		
1 0	5533	6.35000E+01				
2 0	5534	6.42500E+01	6.55200E+01			
1 0	5536	6.60400E+01				
1 0	5584	0.				
5 0	5585	5.00000E-01	1.75000E+00	3.00000E+00	4.75000E+00	7.50000E+00
5 0	5590	1.15000E+01	1.70000E+01	2.35000E+01	3.05000E+01	3.75000E+01
5 0	5595	4.45000E+01	5.15000E+01	5.85000E+01	6.55000E+01	7.25000E+01
5 0	5600	7.95000E+01	8.65000E+01	9.35000E+01	1.00500E+02	1.07500E+02
5 0	5605	1.14500E+02	1.21500E+02	1.27500E+02	1.31500E+02	1.34000E+02
5 0	5610	1.35650E+02	1.36730E+02	1.37580E+02	1.38500E+02	1.39350E+02
1-0	5615	1.40300E+02				
1 0	5635	1.57333E+00				
2 0	5636	1.09908E+00	8.59868E-01			
1 0	5638	7.77738E-01				
1 0	5686	1.09592E-01				
5 0	5687	1.29366E-01	1.95849E-01	2.68646E-01	3.68290E-01	5.27098E-01
5 0	5692	7.48490E-01	1.02410E+00	1.30825E+00	1.56934E+00	1.78575E+00
5 0	5697	1.95923E+00	2.08993E+00	2.17691E+00	2.21941E+00	2.21684E+00
5 0	5702	2.16945E+00	2.07805E+00	1.94417E+00	1.76993E+00	1.55767E+00
5 0	5707	1.31035E+00	1.04183E+00	8.18124E-01	6.87165E-01	6.18104E-01
5 0	5712	5.61336E-01	5.09526E-01	4.66233E-01	4.15600E-01	3.77724E-01
1 1	5717	3.50104E-01				

CALCULATED RESULTS FOR SOURCE REGION 1

REGION NO. 4A RADIAL PRESSURE VESSEL REGION P1

RECEIVER POINT A=0.998

TABLE 2-6 (Continued)

COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	9.063E-12	7.704E-18	9.335E-18
2	7.25	4.602E-13	4.050E-19	4.832E-19
3	6.50	1.796E-12	1.653E-18	1.940E-18
4	5.50	1.310E-12	5.893E-19	1.519E-18
5	4.50	2.336E-12	2.453E-18	2.826E-18
6	3.50	1.125E-12	1.294E-18	1.474E-18
7	2.80	2.870E-13	3.530E-19	4.047E-19
8	2.50	1.612E-13	2.047E-19	2.337E-19
9	2.00	7.929E-14	1.086E-19	1.237E-19
10	1.50	3.228E-13	4.778E-19	5.456E-19
11	1.00	6.891E-15	1.109E-20	1.268E-20
12	.70	9.303E-16	1.554E-21	1.805E-21
13	.30	5.268E-17	8.745E-23	9.957E-23
		---------	---------	---------
		1.695E-11	1.525E-17	1.890E-17

REGION NO. 4A RADIAL PRESSURE VESSEL REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	3.410E-12	2.899E-18	3.513E-18
2	7.25	1.581E-13	1.391E-19	1.660E-19
3	6.50	5.709E-13	5.252E-19	6.166E-19
4	5.50	3.688E-13	1.660E-19	4.279E-19
5	4.50	5.532E-13	5.809E-19	6.694E-19
6	3.50	2.122E-13	2.440E-19	2.780E-19
7	2.80	4.293E-14	5.281E-20	6.054E-20
8	2.50	2.154E-14	2.736E-20	3.123E-20

TABLE 2-6 (Continued)

9	2.00	8.181E-15	1.121E-20	1.276E-20
10	1.50	2.242E-14	3.318E-20	3.789E-20
11	1.00	2.380E-16	3.832E-22	4.379E-22
12	.70	1.498E-17	2.502E-23	2.906E-23
13	.30	1.026E-19	1.704E-25	1.940E-25
		---------	---------	---------
		5.369E-12	4.679E-18	5.813E-18

REGION NO. 4A RADIAL PRESSURE VESSEL REGION P1

RECEIVER POINT A=0.998
COORDINATES R....... 4.08932E+01
Z....... 9.82485E+02
PHI..... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	2.058E-14	2.058E-14	2.058E-14	2.383E-18	3.665E-19
2	9.00	4.748E-14	4.748E-14	4.748E-14	5.227E-18	8.014E-19
3	8.00	7.147E-14	7.147E-14	7.147E-14	7.926E-18	1.224E-18
4	7.00	1.338E-13	1.338E-13	1.338E-13	1.429E-17	2.166E-18
5	6.00	2.968E-13	2.968E-13	2.968E-13	3.169E-17	4.805E-18
6	5.00	7.434E-13	7.434E-13	7.434E-13	7.888E-17	1.192E-17
7	4.00	2.004E-12	2.004E-12	2.004E-12	2.085E-16	2.985E-17
8	3.20	3.292E-12	3.292E-12	3.292E-12	3.221E-16	4.530E-17
9	2.50	1.043E-11	1.043E-11	1.043E-11	9.419E-16	1.229E-16
10	1.80	1.624E-11	1.624E-11	1.624E-11	1.562E-15	1.733E-16
11	1.30	1.607E-11	1.607E-11	1.607E-11	1.500E-15	1.515E-16
12	.95	1.810E-11	0.	1.810E-11	1.539E-15	1.397E-16
13	.70	1.630E-11	0.	1.630E-11	1.135E-15	1.076E-16
14	.50	1.480E-11	0.	1.480E-11	6.451E-16	8.508E-17
15	.40	1.132E-11	0.	1.132E-11	6.051E-16	5.776E-17
16	.30	1.253E-11	0.	1.253E-11	4.990E-16	4.919E-17
17	.20	1.430E-11	0.	1.430E-11	4.977E-16	5.313E-17
18	.10	8.900E-12	0.	8.900E-12	1.736E-16	2.025E-17
19	.09	1.970E-12	0.	0.	3.509E-17	4.202E-18
20	.08	2.207E-12	0.	0.	3.690E-17	4.261E-18
21	.07	2.575E-12	0.	0.	3.532E-17	4.534E-18
22	.06	3.157E-12	0.	0.	3.602E-17	4.906E-18
23	.05	4.724E-12	0.	0.	4.437E-17	6.350E-18
24	.04	6.423E-12	0.	0.	4.628E-17	7.303E-18

TABLE 2-6 (Continued)

25	.03	1.147E-11	0.	0.	5.851E-17	1.026E-17
26	.02	2.318E-11	0.	0.	7.082E-17	1.482E-17
27	.01	2.412E-11	0.	0.	2.842E-17	8.301E-18
		---------	---------	---------	---------	---------
		2.254E-10	4.935E-11	1.456E-10	1.016E-14	1.122E-15

REGION NO. 4A RADIAL PRESSURE VESSEL REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

RADS(E)/HR

1	1.00	6.205E-16

		6.205E-16

FOR SOURCE REGION 1 AND DETECTOR POINT 1 THERE HAS BEEN 390 AND 252 PATH LENGTH CALCULATIONS IN EXCESS OF 20.0 MEAN FREE PATHS(GAMMA RAY) AND 120.0 GRAMS/CM**2(NEUTRON),RESPECTIVELY

INTERMEDIATE SUMMARY RESULTS OVER A SUBSET OF SOURCE REGIONS

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	9.063E-12	7.704E-18	9.335E-18

TABLE 2-6 (Continued)

2	7.25	4.602E-13	4.050E-19	4.832E-19
3	6.50	1.796E-12	1.653E-18	1.940E-18
4	5.50	1.310E-12	5.893E-19	1.519E-18
5	4.50	2.336E-12	2.453E-18	2.826E-18
6	3.50	1.125E-12	1.294E-18	1.474E-18
7	2.80	2.870E-13	3.530E-19	4.047E-19
8	2.50	1.612E-13	2.047E-19	2.337E-19
9	2.00	7.929E-14	1.086E-19	1.237E-19
10	1.50	3.228E-13	4.778E-19	5.456E-19
11	1.00	6.891E-15	1.109E-20	1.268E-20
12	.70	9.303E-16	1.554E-21	1.805E-21
13	.30	5.268E-17	8.745E-23	9.957E-23
		---------	---------	---------
		1.695E-11	1.525E-17	1.890E-17

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R....... 4.08932E+01
Z....... 9.82485E+02
PHI..... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	3.410E-12	2.899E-18	3.513E-18
2	7.25	1.581E-13	1.391E-19	1.660E-19
3	6.50	5.709E-13	5.252E-19	6.166E-19
4	5.50	3.688E-13	1.660E-19	4.279E-19
5	4.50	5.532E-13	5.809E-19	6.694E-19
6	3.50	2.122E-13	2.440E-19	2.780E-19
7	2.80	4.293E-14	5.281E-20	6.054E-20
8	2.50	2.154E-14	2.736E-20	3.123E-20
9	2.00	8.181E-15	1.121E-20	1.276E-20
10	1.50	2.242E-14	3.318E-20	3.789E-20
11	1.00	2.380E-16	3.832E-22	4.379E-22
12	.70	1.498E-17	2.502E-23	2.906E-23
13	.30	1.026E-19	1.704E-25	1.940E-25
		---------	---------	---------
		5.369E-12	4.679E-18	5.813E-18

EXTRA CORE REGIONS - TOTAL

TABLE 2-6 (Continued)

```
RECEIVER POINT  A=0.998
COORDINATES R......     4.08932E+01
            Z......     9.82485E+02
            PHI....     0.

         RADS(E)/HR

1  1.00   6.205E-16
          ---------
          6.205E-16
```

TABLE 2-6 (Continued)

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	2.058E-14	2.058E-14	2.058E-14	2.383E-18	3.665E-19
2	9.00	4.748E-14	4.748E-14	4.748E-14	5.227E-18	8.014E-19
3	8.00	7.147E-14	7.147E-14	7.147E-14	7.926E-18	1.224E-18
4	7.00	1.338E-13	1.338E-13	1.338E-13	1.429E-17	2.166E-18
5	6.00	2.968E-13	2.968E-13	2.968E-13	3.169E-17	4.805E-18
6	5.00	7.434E-13	7.434E-13	7.434E-13	7.888E-17	1.192E-17
7	4.00	2.004E-12	2.004E-12	2.004E-12	2.085E-16	2.985E-17
8	3.20	3.292E-12	3.292E-12	3.292E-12	3.221E-16	4.530E-17
9	2.50	1.043E-11	1.043E-11	1.043E-11	9.419E-16	1.229E-16
10	1.80	1.624E-11	1.624E-11	1.624E-11	1.562E-15	1.733E-16
11	1.30	1.607E-11	1.607E-11	1.607E-11	1.500E-15	1.515E-16
12	.95	1.810E-11	0.	1.810E-11	1.539E-15	1.397E-16
13	.70	1.630E-11	0.	1.630E-11	1.135E-15	1.076E-16
14	.50	1.480E-11	0.	1.480E-11	6.457E-16	8.508E-17
15	.40	1.132E-11	0.	1.132E-11	6.051E-16	5.776E-17
16	.30	1.253E-11	0.	1.253E-11	4.990E-16	4.919E-17
17	.20	1.430E-11	0.	1.430E-11	4.977E-16	5.313E-17
18	.10	8.900E-12	0.	8.900E-12	1.736E-16	2.025E-17
19	.09	1.970E-12	0.	0.	3.509E-17	4.202E-18
20	.08	2.207E-12	0.	0.	3.690E-17	4.261E-18
21	.07	2.575E-12	0.	0.	3.532E-17	4.534E-18
22	.06	3.157E-12	0.	0.	3.602E-17	4.906E-18
23	.05	4.724E-12	0.	0.	4.437E-17	6.350E-18
24	.04	6.423E-12	0.	0.	4.628E-17	7.303E-18
25	.03	1.147E-11	0.	0.	5.851E-17	1.026E-17
26	.02	2.318E-11	0.	0.	7.082E-17	1.482E-17
27	.01	2.412E-11	0.	0.	2.842E-17	8.301E-18
		---------	---------	---------	---------	---------
		2.254E-10	4.935E-11	1.456E-10	1.016E-14	1.122E-15

EXTRA CORE REGIONS - TOTAL

TABLE 2-6 (Continued)

MSFC SAMPLE PROBLEM - SOURCE DATA FROM NAGS
- GEOM. - 75 D. PROP. TANK
- MERIDIAN RING COS(A)=1.0 TO 0.9

2-0	50	1 7				
1-0	52	18				
2 1	75	4 49				
2-0	7	6.35000E+01	6.60400E+01			
5-0	28	1.40300E+02	1.45000E+02	1.55000E+02	1.65000E+02	1.75000E+02
3-0	33	1.95000E+02	2.05000E+02	2.15900E+02		
2-0	1	1.00000E+00	0.			
5 0	1400	8.57492E-03	4.96391E-04	2.30521E-03	2.10969E-03	5.65985E-03
5 0	1405	4.43303E-03	1.95834E-03	1.33418E-03	1.11629E-03	1.04117E-02
3 0	1410	7.90781E-04	2.94292E-04	3.01566E-04		
1 0	5533	6.35000E+01				
2 0	5534	6.42500E+01	6.55200E+01			
1 0	5536	6.60400E+01				
5 0	5584	1.40300E+02	1.42400E+02	1.45900E+02	1.49900E+02	1.53420E+02
5 0	5589	1.55005E+02	1.55135E+02	1.55265E+02	1.55395E+02	1.55525E+02
5 0	5594	1.55655E+02	1.55785E+02	1.55945E+02	1.56240E+02	1.56740E+02
5 0	5599	1.57590E+02	1.58690E+02	1.59990E+02	1.61490E+02	1.62990E+02
5 0	5604	1.64490E+02	1.66240E+02	1.68240E+02	1.70240E+02	1.72240E+02
5 0	5609	1.74240E+02	1.76240E+02	1.78240E+02	1.80240E+02	1.82240E+02
5 0	5614	1.84240E+02	1.85990E+02	1.87490E+02	1.88740E+02	1.89740E+02
5 0	5619	1.90590E+02	1.91290E+02	1.91840E+02	1.92140E+02	1.92340E+02
5 0	5624	1.92540E+02	1.92740E+02	1.92890E+02	1.92990E+02	1.95520E+02
3 0	5629	2.01000E+02	2.07000E+02	2.12950E+02		
1 0	5634	2.15900E+02				
5 0	5686	3.50104E-01	2.90578E-01	2.00018E-01	1.11193E-01	5.37184E-02
5 0	5691	3.26822E-02	3.11182E-02	2.93873E-02	2.75044E-02	2.54854E-02
5 0	5696	2.38802E-02	2.21157E-02	2.01318E-02	1.71852E-02	1.35559E-02
5 0	5701	1.04774E-02	8.02487E-03	5.74968E-03	4.22404E-03	3.57458E-03
5 0	5706	3.26294E-03	2.90605E-03	2.30569E-03	1.70168E-03	1.18488E-03
5 0	5711	8.23674E-04	5.70436E-04	3.98089E-04	2.82405E-04	1.97120E-04
5 0	5716	1.42185E-04	1.02101E-04	7.77541E-05	6.56594E-05	5.59178E-05
5 0	5721	4.97608E-05	4.73509E-05	4.53692E-05	4.39562E-05	4.30642E-05
5 0	5726	4.22305E-05	4.12126E-05	4.04230E-05	3.99477E-05	3.32984E-05
3 0	5731	2.99381E-05	3.05006E-05	2.42797E-05		
1 1	5736	2.06522E-05				

CALCULATED RESULTS FOR SOURCE REGION 1

REGION NO. 48 RADIAL PRESSURE VESSEL REGION P1

TABLE 2-6 (Continued)

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	8.345E-11	7.093E-17	8.595E-17
2	7.25	4.644E-12	4.087E-18	4.876E-18
3	6.50	1.970E-11	1.812E-17	2.128E-17
4	5.50	1.615E-11	7.267E-18	1.873E-17
5	4.50	3.443E-11	3.615E-17	4.166E-17
6	3.50	2.079E-11	2.391E-17	2.724E-17
7	2.80	6.704E-12	8.246E-18	9.453E-18
8	2.50	4.144E-12	5.263E-18	6.009E-18
9	2.00	2.534E-12	3.471E-18	3.952E-18
10	1.50	1.403E-11	2.077E-17	2.372E-17
11	1.00	4.727E-13	7.610E-19	8.697E-19
12	.70	9.554E-14	1.596E-19	1.854E-19
13	.30	3.011E-14	4.997E-20	5.690E-20
		---------	---------	---------
		2.072E-10	1.992E-16	2.440E-16

REGION NO. 48 RADIAL PRESSURE VESSEL REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	4.004E-11	3.403E-17	4.124E-17
2	7.25	2.066E-12	1.818E-18	2.169E-18
3	6.50	8.184E-12	7.530E-18	8.839E-18
4	5.50	6.030E-12	2.713E-18	6.995E-18
5	4.50	1.097E-11	1.152E-17	1.328E-17
6	3.50	5.377E-12	6.183E-18	7.043E-18

7	2.80	1.400E-12	1.722E-18	1.974E-18
8	2.50	7.816E-13	9.926E-19	1.133E-18
9	2.00	3.802E-13	5.208E-19	5.931E-19
10	1.50	1.529E-12	2.263E-18	2.584E-18
11	1.00	3.378E-14	5.439E-20	6.216E-20
12	.70	5.370E-15	8.968E-21	1.042E-20
13	.30	1.578E-15	2.620E-21	2.983E-21
		---------	---------	---------
		7.680E-11	6.936E-17	8.592E-17

REGION NO. 48 RADIAL PRESSURE VESSEL REGION P1

RECEIVER POINT A=0.998
COORDINATES R....... 4.08932E+01
Z....... 9.82485E+02
PHI.... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	1.580E-12	1.580E-12	1.580E-12	1.830E-16	2.815E-17
2	9.00	3.803E-12	3.803E-12	3.803E-12	4.187E-16	6.419E-17
3	8.00	5.977E-12	5.977E-12	5.977E-12	6.629E-16	1.0[illegible]3E-16
4	7.00	1.162E-11	1.162E-11	1.162E-11	1.241E-15	1.881E-16
5	6.00	2.653E-11	2.653E-11	2.653E-11	2.833E-15	4.295E-16
6	5.00	6.772E-11	6.772E-11	6.772E-11	7.186E-15	1.086E-15
7	4.00	1.845E-10	1.845E-10	1.845E-10	1.919E-14	2.747E-15
8	3.20	2.506E-10	2.506E-10	2.506E-10	2.452E-14	3.448E-15
9	2.50	6.764E-10	6.764E-10	6.764E-10	6.110E-14	7.975E-15
10	1.80	1.000E-09	1.000E-09	1.000E-09	9.619E-14	1.057E-14
11	1.30	1.057E-09	1.057E-09	1.057E-09	9.867E-14	9.963E-15
12	.95	1.129E-09	0.	1.129E-09	9.599E-14	8.715E-15
13	.70	1.003E-09	0.	1.003E-09	6.980E-14	6.616E-15
14	.50	9.242E-10	0.	9.242E-10	4.027E-14	5.312E-15
15	.40	6.777E-10	0.	6.777E-10	3.622E-14	3.457E-15
16	.30	7.417E-10	0.	7.417E-10	2.954E-14	2.913E-15
17	.20	8.076E-10	0.	8.076E-10	2.811E-14	3.001E-15
18	.10	4.811E-10	0.	4.811E-10	9.386E-15	1.094E-15
19	.09	1.029E-10	0.	0.	1.833E-15	2.195E-16
20	.08	1.140E-10	0.	0.	1.906E-15	2.201E-16
21	.07	1.278E-10	0.	0.	1.753E-15	2.250E-16
22	.06	1.500E-10	0.	0.	1.712E-15	2.332E-16

3

TABLE 2-6 (Continued)

23	.05	1.910E-10	0.	0.	1.794E-15	2.568E-16
24	.04	2.729E-10	0.	0.	1.967E-15	3.103E-16
25	.03	4.530E-10	0.	0.	2.311E-15	4.053E-16
26	.02	9.050E-10	0.	0.	2.766E-15	5.788E-16
27	.01	1.128E-09	0.	0.	1.329E-15	3.882E-16
		---------	---------	---------	---------	---------
		1.249E-08	3.286E-09	9.050E-09	6.389E-13	7.065E-14

REGION NO. 48 RADIAL PRESSURE VESSEL REGION P1

RECEIVER POINT A=0.998
COORDINATES R....... 4.08932E+01
Z....... 9.82485E+02
PHI..... 0.

RADS(E)/HR

1	1.00	3.178E-14

		3.178E-14

FOR SOURCE REGION 1 AND DETECTOR POINT 1 THERE HAS BEEN 0 AND 0 PATH LENGTH CALCULATIONS IN EXCESS OF 20.0 MEAN FREE PATHS(GAMMA RAY) AND 120.0 GRAMS/CM**2(NEUTRON),RESPECTIVELY

INTERMEDIATE SUMMARY RESULTS OVER A SUBSET OF SOURCE REGIONS

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R....... 4.08932E+01
Z....... 9.82485E+02
PHI..... 0.

MEV/CM2-SEC RADS(C)/HR REM/HR

TABLE 2-6 (Continued)

1	8.50	8.345E-11	7.093E-17	8.595E-17
2	7.25	4.644E-12	4.087E-18	4.876E-18
3	6.50	1.970E-11	1.812E-17	2.128E-17
4	5.50	1.615E-11	7.267E-18	1.873E-17
5	4.50	3.443E-11	3.615E-17	4.166E-17
6	3.50	2.079E-11	2.391E-17	2.724E-17
7	2.80	6.704E-12	8.246E-18	9.453E-18
8	2.50	4.144E-12	5.263E-18	6.009E-18
9	2.00	2.534E-12	3.471E-18	3.952E-18
10	1.50	1.403E-11	2.077E-17	2.372E-17
11	1.00	4.727E-13	7.610E-19	8.697E-19
12	.70	9.554E-14	1.596E-19	1.854E-19
13	.30	3.011E-14	4.997E-20	5.690E-20
		---------	---------	---------
		2.072E-10	1.992E-16	2.440E-16

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	4.004E-11	3.403E-17	4.124E-17
2	7.25	2.066E-12	1.818E-18	2.169E-18
3	6.50	8.184E-12	7.530E-18	8.839E-18
4	5.50	6.030E-12	2.713E-18	6.995E-18
5	4.50	1.097E-11	1.152E-17	1.328E-17
6	3.50	5.377E-12	6.183E-18	7.043E-18
7	2.80	1.400E-12	1.722E-18	1.974E-18
8	2.50	7.816E-13	9.926E-19	1.133E-18
9	2.00	3.802E-13	5.208E-19	5.931E-19
10	1.50	1.529E-12	2.263E-18	2.584E-18
11	1.00	3.378E-14	5.439E-20	6.216E-20
12	.70	5.370E-15	8.968E-21	1.042E-20
13	.30	1.578E-15	2.620E-21	2.983E-21
		---------	---------	---------
		7.680E-11	6.936E-17	8.592E-17

TABLE 2-6 (Continued)

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	1.580E-12	1.580E-12	1.580E-12	1.830E-16	2.815E-17
2	9.00	3.803E-12	3.803E-12	3.803E-12	4.187E-16	6.419E-17
3	8.00	5.977E-12	5.977E-12	5.977E-12	6.629E-16	1.023E-16
4	7.00	1.162E-11	1.162E-11	1.162E-11	1.241E-15	1.881E-16
5	6.00	2.653E-11	2.653E-11	2.653E-11	2.833E-15	4.295E-16
6	5.00	6.772E-11	6.772E-11	6.772E-11	7.186E-15	1.086E-15
7	4.00	1.845E-10	1.845E-10	1.845E-10	1.919E-14	2.747E-15
8	3.20	2.506E-10	2.506E-10	2.506E-10	2.452E-14	3.448E-15
9	2.50	6.764E-10	6.764E-10	6.764E-10	6.110E-14	7.975E-15
10	1.80	1.000E-09	1.000E-09	1.000E-09	9.619E-14	1.067E-14
11	1.30	1.057E-09	1.057E-09	1.057E-09	9.867E-14	9.963E-15
12	.95	1.129E-09	0.	1.129E-09	9.599E-14	8.715E-15
13	.70	1.003E-09	0.	1.003E-09	6.980E-14	6.616E-15
14	.50	9.242E-10	0.	9.242E-10	4.027E-14	5.312E-15
15	.40	6.777E-10	0.	6.777E-10	3.622E-14	3.457E-15
16	.30	7.417E-10	0.	7.417E-10	2.954E-14	2.913E-15
17	.20	8.076E-10	0.	8.076E-10	2.811E-14	3.001E-15
18	.10	4.811E-10	0.	4.811E-10	9.386E-15	1.094E-15
19	.09	1.029E-10	0.	0.	1.833E-15	2.195E-16
20	.08	1.140E-10	0.	0.	1.906E-15	2.201E-16
21	.07	1.278E-10	0.	0.	1.753E-15	2.250E-16
22	.06	1.500E-10	0.	0.	1.712E-15	2.332E-16
23	.05	1.910E-10	0.	0.	1.794E-15	2.568E-16
24	.04	2.729E-10	0.	0.	1.967E-15	3.103E-16
25	.03	4.530E-10	0.	0.	2.311E-15	4.053E-16
26	.02	9.050E-10	0.	0.	2.766E-15	5.788E-16
27	.01	1.128E-09	0.	0.	1.329E-15	3.882E-16
		---------	---------	---------	---------	---------
		1.249E-08	3.286E-09	9.050E-09	6.389E-13	7.065E-14

EXTRA CORE REGIONS - TOTAL

TABLE 2-6 (Continued)

```
RECEIVER POINT  A=0.998
COORDINATES R......     4.08932E+01
            Z......     9.82485E+02
            PHI....     0.

           RADS(E)/HR

1  1.00    3.178E-14
           ---------
           3.178E-14
```


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TABLE 2-6 (Continued)

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      MSFC SAMPLE PROBLEM - SOURCE DATA FROM NAGS
                          - GEOM. - 75 D. PROP. TANK
                          - MERIDIAN RING COS(A)=1.0 TO 0.9
2-0        50   7   2
7-0        52   2   4   6   8  10  12  14
2 1        75  34   5
5-0         7  0.            1.00000E+01  2.00000E+01  3.00000E+01  4.00000E+01
3-0        12  5.00000E+01  6.00000E+01  6.35000E+01
3-0        28  1.37160E+02  1.38500E+02  1.39700E+02
2-0         1  1.00000E+00  0.
5 0      1400  0.           0.           0.           0.           0.
5 0      1405  0.           0.           8.00756E-03  0.           0.
3 0      1410  0.           0.           0.
1 0      5533  0.
5 0      5534  3.50000E+00  9.50000E+00  1.40000E+01  1.80000E+01  2.20000E+01
5 0      5539  2.60000E+01  3.00000E+01  3.35000E+01  3.65000E+01  3.90000E+01
5 0      5544  4.10000E+01  4.27500E+01  4.42500E+01  4.55000E+01  4.65000E+01
5 0      5549  4.73750E+01  4.81250E+01  4.87500E+01  4.92500E+01  4.97500E+01
5 0      5554  5.02000E+01  5.06000E+01  5.10500E+01  5.16500E+01  5.25000E+01
5 0      5559  5.37500E+01  5.51900E+01  5.66900E+01  5.82500E+01  5.97500E+01
2 0      5564  6.12500E+01  6.27500E+01
1 0      5566  6.35000E+01
1 0      5584  1.37160E+02
3 0      5585  1.37580E+02  1.38500E+02  1.39350E+02
1 0      5588  1.39700E+02
1 0      5635  1.57785E+00
5 0      5636  1.57503E+00  1.55704E+00  1.53032E+00  1.49532E+00  1.44868E+00
5 0      5641  1.38897E+00  1.31504E+00  1.23925E+00  1.16540E+00  1.09954E+00
5 0      5646  1.04469E+00  9.96595E-01  9.57025E-01  9.26504E-01  9.05570E-01
5 0      5651  8.90535E-01  8.81639E-01  8.77452E-01  8.77439E-01  8.80886E-01
5 0      5656  8.87008E-01  8.94247E-01  9.03334E-01  9.14924E-01  9.22789E-01
5 0      5661  9.13965E-01  8.81094E-01  8.10504E-01  6.93901E-01  5.41997E-01
2 0      5666  3.73386E-01  1.86906E-01
1 0      5668  1.31714E-01
1 0      5686  7.71813E-01
3 0      5687  8.76655E-01  1.06448E+00  1.05590E+00
1 1      5690  1.02474E+00

           CALCULATED RESULTS FOR SOURCE REGION    1

                      REGION NO. 5 AXIAL PLENUM REGION           P1
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TABLE 2-6 (Continued)

```
RECEIVER POINT  A=0.998
COORDINATES R.......    4.08932E+01
            Z.......    9.82485E+02
            PHI.....    0.
```

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	0.	0.	0.
2	7.25	0.	0.	0.
3	6.50	0.	0.	0.
4	5.50	0.	0.	0.
5	4.50	0.	0.	0.
6	3.50	0.	0.	0.
7	2.80	0.	0.	0.
8	2.50	7.162E-11	9.095E-17	1.038E-16
9	2.00	0.	0.	0.
10	1.50	0.	0.	0.
11	1.00	0.	0.	0.
12	.70	0.	0.	0.
13	.30	0.	0.	0.
		---------	---------	---------
		7.162E-11	9.V95E-17	1.038E-16

REGION NO. 5 AXIAL PLENUM REGION P1

```
RECEIVER POINT  A=0.998
COORDINATES R.......    4.08932E+01
            Z.......    9.82485E+02
            PHI.....    0.
```

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	0.	0.	0.
2	7.25	0.	0.	0.
3	6.50	0.	0.	0.
4	5.50	0.	0.	0.
5	4.50	0.	0.	0.
6	3.50	0.	0.	0.
7	2.80	0.	0.	0.

TABLE 2-6 (Continued)

8	2.50	1.678E-11	2.131E-17	2.433E-17
9	2.00	0.	0.	0.
10	1.50	0.	0.	0.
11	1.00	0.	0.	0.
12	.70	0.	0.	0.
13	.30	0.	0.	0.
		---------	---------	---------
		1.678E-11	2.131E-17	2.433E-17

REGION NO. 5 AXIAL PLENUM REGION P1

RECEIVER POINT A=0.998
COORDINATES R....... 4.08932E+01
Z....... 9.82485E+02
PHI..... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	2.769E-12	2.769E-12	2.769E-12	3.207E-16	4.932E-17
2	9.00	7.008E-12	7.008E-12	7.008E-12	7.715E-16	1.183E-16
3	8.00	1.156E-11	1.156E-11	1.156E-11	1.282E-15	1.979E-16
4	7.00	2.360E-11	2.360E-11	2.360E-11	2.520E-15	3.821E-16
5	6.00	5.663E-11	5.663E-11	5.663E-11	6.048E-15	9.168E-16
6	5.00	1.516E-10	1.516E-10	1.516E-10	1.609E-14	2.430E-15
7	4.00	4.301E-10	4.301E-10	4.301E-10	4.473E-14	6.404E-15
8	3.20	5.986E-10	5.986E-10	5.986E-10	5.857E-14	8.237E-15
9	2.50	1.637E-09	1.637E-09	1.637E-09	1.479E-13	1.930E-14
10	1.80	2.431E-09	2.431E-09	2.431E-09	2.337E-13	2.594E-14
11	1.30	2.559E-09	2.559E-09	2.559E-09	2.389E-13	2.412E-14
12	.95	2.530E-09	0.	2.530E-09	2.151E-13	1.953E-14
13	.70	2.316E-09	0.	2.316E-09	1.613E-13	1.529E-14
14	.50	2.123E-09	0.	2.123E-09	9.253E-14	1.220E-14
15	.40	1.538E-09	0.	1.538E-09	8.218E-14	7.845E-15
16	.30	1.651E-09	0.	1.651E-09	6.576E-14	6.484E-15
17	.20	1.752E-09	0.	1.752E-09	6.099E-14	6.511E-15
18	.10	1.010E-09	0.	1.010E-09	1.971E-14	2.299E-15
19	.09	2.180E-10	0.	0.	3.882E-15	4.649E-16
20	.08	2.373E-10	0.	0.	3.967E-15	4.582E-16
21	.07	2.576E-10	0.	0.	3.535E-15	4.537E-16
22	.06	2.913E-10	0.	0.	3.324E-15	4.527E-16
23	.05	3.584E-10	0.	0.	3.366E-15	4.816E-16

24	.04	5.002E-10	0.	0.	3.604E-15	5.687E-16
25	.03	8.283E-10	0.	0.	4.225E-15	7.410E-16
26	.02	1.698E-09	0.	0.	5.188E-15	1.086E-15
27	.01	2.248E-09	0.	0.	2.648E-15	7.735E-16
		---------	---------	---------	---------	---------
		2.747E-08	7.909E-09	2.083E-08	1.482E-12	1.637E-13

REGION NO. 5 AXIAL PLENUM REGION P1

RECEIVER POINT A=0.998
COORDINATES R....... 4.08932E+01
Z....... 9.82485E+02
PHI..... 0.

RADS(E)/HR

1 1.00 4.911E-14

4.911E-14

FOR SOURCE REGION 1 AND DETECTOR POINT 1 THERE HAS BEEN 0 AND 28 PATH LENGTH CALCULATIONS IN EXCESS OF 20.0 MEAN FREE PATHS(GAMMA RAY) AND 120.0 GRAMS/CM**2(NEUTRON),RESPECTIVELY

INTERMEDIATE SUMMARY RESULTS OVER A SUBSET OF SOURCE REGIONS

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R....... 4.08932E+01
Z....... 9.82485E+02
PHI..... 0.

MEV/CM2-SEC RADS(C)/HR REM/HR

TABLE 2-6 (Continued)

1	8.50	0.	0.	0.
2	7.25	0.	0.	0.
3	6.50	0.	0.	0.
4	5.50	0.	0.	0.
5	4.50	0.	0.	0.
6	3.50	0.	0.	0.
7	2.80	0.	0.	0.
8	2.50	7.162E-11	9.095E-17	1.038E-16
9	2.00	0.	0.	0.
10	1.50	0.	0.	0.
11	1.00	0.	0.	0.
12	.70	0.	0.	0.
13	.30	0.	0.	0.
		---------	---------	---------
		7.162E-11	9.095E-17	1.038E-16

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	0.	0.	0.
2	7.25	0.	0.	0.
3	6.50	0.	0.	0.
4	5.50	0.	0.	0.
5	4.50	0.	0.	0.
6	3.50	0.	0.	0.
7	2.80	0.	0.	0.
8	2.50	1.678E-11	2.131E-17	2.433E-17
9	2.00	0.	0.	0.
10	1.50	0.	0.	0.
11	1.00	0.	0.	0.
12	.70	0.	0.	0.
13	.30	0.	0.	0.
		---------	---------	---------
		1.678E-11	2.131E-17	2.433E-17

TABLE 2-6 (Continued)

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	2.769E-12	2.769E-12	2.769E-12	3.207E-16	4.932E-17
2	9.00	7.008E-12	7.008E-12	7.008E-12	7.715E-16	1.183E-16
3	8.00	1.156E-11	1.156E-11	1.156E-11	1.282E-15	1.979E-16
4	7.00	2.360E-11	2.360E-11	2.360E-11	2.520E-15	3.821E-16
5	6.00	5.663E-11	5.663E-11	5.663E-11	6.048E-15	9.168E-16
6	5.00	1.516E-10	1.516E-10	1.516E-10	1.609E-14	2.430E-15
7	4.00	4.301E-10	4.301E-10	4.301E-10	4.473E-14	6.404E-15
8	3.20	5.986E-10	5.986E-10	5.986E-10	5.857E-14	8.237E-15
9	2.50	1.637E-09	1.637E-09	1.637E-09	1.479E-13	1.930E-14
10	1.80	2.431E-09	2.431E-09	2.431E-09	2.337E-13	2.594E-14
11	1.30	2.559E-09	2.559E-09	2.559E-09	2.389E-13	2.412E-14
12	.95	2.530E-09	0.	2.530E-09	2.151E-13	1.953E-14
13	.70	2.316E-09	0.	2.316E-09	1.613E-13	1.529E-14
14	.50	2.123E-09	0.	2.123E-09	9.253E-14	1.220E-14
15	.40	1.538E-09	0.	1.538E-09	8.218E-14	7.845E-15
16	.30	1.651E-09	0.	1.651E-09	6.576E-14	6.484E-15
17	.20	1.752E-09	0.	1.752E-09	6.099E-14	6.511E-15
18	.10	1.010E-09	0.	1.010E-09	1.971E-14	2.299E-15
19	.09	2.180E-10	0.	0.	3.882E-15	4.649E-16
20	.08	2.373E-10	0.	0.	3.967E-15	4.582E-16
21	.07	2.576E-10	0.	0.	3.535E-15	4.537E-16
22	.06	2.913E-10	0.	0.	3.324E-15	4.527E-16
23	.05	3.584E-10	0.	0.	3.366E-15	4.816E-16
24	.04	5.002E-10	0.	0.	3.604E-15	5.687E-16
25	.03	8.283E-10	0.	0.	4.225E-15	7.410E-16
26	.02	1.698E-09	0.	0.	5.188E-15	1.086E-15
27	.01	2.248E-09	0.	0.	2.648E-15	7.735E-16
		2.747E-08	7.909E-09	2.083E-08	1.482E-12	1.637E-13

EXTRA CORE REGIONS - TOTAL

TABLE 2-6 (Continued)

```
RECEIVER POINT  A=0.998
COORDINATES R.......     4.08932E+01
            Z.......     9.82485E+02
            PHI.....     0.

        RADS(E)/HR

1  1.00    4.911E-14
           ---------
           4.911E-14
```

TABLE 2-6 (Continued)

```
     MSFC SAMPLE PROBLEM - SOURCE DATA FROM NAGS
                         - GEOM. - 75 D. PROP. TANK
                         - MERIDIAN RING COS(A)=1.0 TO 0.9
2-0          50   2   2
2-0          52  14  14
2 1          75   7   7
3-0           7  5.58800E+01  6.00000E+01  6.35000E+01
3-0          28  1.39700E+02  1.45000E+02  1.54940E+02
2-0           1  1.00000E+00  0.
5 0        1400  0.           0.           0.           0.           0.
5 0        1405  0.           0.           2.72283E-03  0.           0.
3 0        1410  0.           0.           0.
1 0        5533  5.58800E+01
5 0        5534  5.66900E+01  5.82500E+01  5.97500E+01  6.12500E+01  6.27500E+01
1 0        5539  6.35000E+01
1 0        5584  1.39700E+02
5 0        5585  1.40300E+02  1.42400E+02  1.45900E+02  1.49900E+02  1.53420E+02
1 0        5590  1.54940E+02
1 0        5635  1.69091E+00
5 0        5636  1.64585E+00  1.38641E+00  1.02414E+00  6.66063E-01  3.14112E-01
1 0        5641  2.16772E-01
1 0        5686  1.94562E+00
5 0        5687  1.86006E+00  1.56647E+00  1.13489E+00  7.13016E-01  3.01609E-01
1 1        5692  6.35821E-02

           CALCULATED RESULTS FOR SOURCE REGION . 1

                         REGION NO. 6 AXIAL PLENUM REGION             P1


RECEIVER POINT  A=0.998
COORDINATES R.......     4.08932E+01
            Z.......     9.82485E+02
            PHI.....     0.

          MEV/CM2-SEC  RADS(C)/HR    REM/HR

1  8.50   0.           0.           0.
2  7.25   0.           0.           0.
3  6.50   0.           0.           0.
4  5.50   0.           0.           0.
```


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TABLE 2-6 (Continued)

5	4.50	0.	0.	0.
6	3.50	0.	0.	0.
7	2.80	0.	0.	0.
8	2.50	1.302E-11	1.653E-17	1.887E-17
9	2.00	0.	0.	0.
10	1.50	0.	0.	0.
11	1.00	0.	0.	0.
12	.70	0.	0.	0.
13	.30	0.	0.	0.
		---------	---------	---------
		1.302E-11	1.653E-17	1.887E-17

REGION NO. 6 AXIAL PLENUM REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI..... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	0.	0.	0.
2	7.25	0.	0.	0.
3	6.50	0.	0.	0.
4	5.50	0.	0.	0.
5	4.50	0.	0.	0.
6	3.50	0.	0.	0.
7	2.80	0.	0.	0.
8	2.50	2.647E-12	3.362E-18	3.839E-18
9	2.00	0.	0.	0.
10	1.50	0.	0.	0.
11	1.00	0.	0.	0.
12	.70	0.	0.	0.
13	.30	0.	0.	0.
		---------	---------	---------
		2.647E-12	3.362E-18	3.839E-18

REGION NO. 6 AXIAL PLENUM REGION P1

TABLE 2-6 (Continued)

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	1.436E-12	1.436E-12	1.436E-12	1.663E-16	2.558E-17
2	9.00	3.448E-12	3.448E-12	3.448E-12	3.796E-16	5.820E-17
3	8.00	5.413E-12	5.413E-12	5.413E-12	6.004E-16	9.268E-17
4	7.00	1.057E-11	1.057E-11	1.057E-11	1.129E-15	1.712E-16
5	6.00	2.442E-11	2.442E-11	2.442E-11	2.608E-15	3.953E-16
6	5.00	6.340E-11	6.340E-11	6.340E-11	6.726E-15	1.016E-15
7	4.00	1.759E-10	1.759E-10	1.759E-10	1.829E-14	2.619E-15
8	3.20	2.454E-10	2.454E-10	2.454E-10	2.401E-14	3.376E-15
9	2.50	6.748E-10	6.748E-10	6.748E-10	6.096E-14	7.956E-15
10	1.80	1.006E-09	1.006E-09	1.006E-09	9.675E-14	1.074E-14
11	1.30	1.060E-09	1.060E-09	1.060E-09	9.896E-14	9.993E-15
12	.95	1.101E-09	0.	1.101E-09	9.363E-14	8.501E-15
13	.70	9.938E-10	0.	9.938E-10	6.920E-14	6.558E-15
14	.50	9.142E-10	0.	9.142E-10	3.984E-14	5.255E-15
15	.40	6.691E-10	0.	6.691E-10	3.576E-14	3.413E-15
16	.30	7.273E-10	0.	7.273E-10	2.897E-14	2.856E-15
17	.20	7.864E-10	0.	7.864E-10	2.738E-14	2.922E-15
18	.10	4.641E-10	0.	4.641E-10	9.054E-15	1.056E-15
19	.09	9.964E-11	0.	0.	1.775E-15	2.125E-16
20	.08	1.099E-10	0.	0.	1.837E-15	2.122E-16
21	.07	1.224E-10	0.	0.	1.679E-15	2.155E-16
22	.06	1.427E-10	0.	0.	1.629E-15	2.218E-16
23	.05	1.824E-10	0.	0.	1.713E-15	2.451E-16
24	.04	2.589E-10	0.	0.	1.865E-15	2.943E-16
25	.03	4.334E-10	0.	0.	2.211E-15	3.878E-16
26	.02	8.766E-10	0.	0.	2.679E-15	5.607E-16
27	.01	1.103E-09	0.	0.	1.299E-15	3.794E-16
		---------	---------	---------	---------	---------
		1.226E-08	3.471E-09	8.927E-09	6.311E-13	6.973E-14

REGION NO. 6 AXIAL PLENUM REGION P1

```
RECEIVER POINT  A=0.998
COORDINATES R......    4.08932E+01
            Z......    9.82485E+02
            PHI....    0.

          RADS(E)/HR

1  1.00   2.281E-14
          ---------
          2.281E-14
```

FOR SOURCE REGION 1 AND DETECTOR POINT 1 THERE HAS BEEN 0 AND 28 PATH LENGTH CALCULATIONS IN EXCESS OF 20.0 MEAN FREE PATHS(GAMMA RAY) AND 120.0 GRAMS/CM**2(NEUTRON),RESPECTIVELY

INTERMEDIATE SUMMARY RESULTS OVER A SUBSET OF SOURCE REGIONS

EXTRA CORE REGIONS - TOTAL

```
RECEIVER POINT  A=0.998
COORDINATES R......    4.08932E+01
            Z......    9.82485E+02
            PHI....    0.
```

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	0.	0.	0.
2	7.25	0.	0.	0.
3	6.50	0.	0.	0.
4	5.50	0.	0.	0.
5	4.50	0.	0.	0.
6	3.50	0.	0.	0.
7	2.80	0.	0.	0.
8	2.50	1.302E-11	1.653E-17	1.887E-17
9	2.00	0.	0.	0.
10	1.50	0.	0.	0.
11	1.00	0.	0.	0.
12	.70	0.	0.	0.
13	.30	0.	0.	0.

TABLE 2-6 (Continued)

---------	---------	---------
1.302E-11	1.653E-17	1.887E-17

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	0.	0.	0.
2	7.25	0.	0.	0.
3	6.50	0.	0.	0.
4	5.50	0.	0.	0.
5	4.50	0.	0.	0.
6	3.50	0.	0.	0.
7	2.80	0.	0.	0.
8	2.50	2.647E-12	3.362E-18	3.839E-18
9	2.00	0.	0.	0.
10	1.50	0.	0.	0.
11	1.00	0.	0.	0.
12	.70	0.	0.	0.
13	.30	0.	0.	0.
		---------	---------	---------
		2.647E-12	3.362E-18	3.839E-18

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR

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TABLE 2-6 (Continued)

1	10.00	1.436E-12	1.436E-12	1.436E-12	1.663E-16	2.558E-17
2	9.00	3.448E-12	3.448E-12	3.448E-12	3.796E-16	5.820E-17
3	8.00	5.413E-12	5.413E-12	5.413E-12	6.004E-16	9.268E-17
4	7.00	1.057E-11	1.057E-11	1.057E-11	1.129E-15	1.712E-16
5	6.00	2.442E-11	2.442E-11	2.442E-11	2.608E-15	3.953E-16
6	5.00	6.340E-11	6.340E-11	6.340E-11	6.726E-15	1.016E-15
7	4.00	1.759E-10	1.759E-10	1.759E-10	1.829E-14	2.619E-15
8	3.20	2.454E-10	2.454E-10	2.454E-10	2.401E-14	3.376E-15
9	2.50	6.748E-10	6.748E-10	6.748E-10	6.096E-14	7.956E-15
10	1.80	1.006E-09	1.006E-09	1.006E-09	9.675E-14	1.074E-14
11	1.30	1.060E-09	1.060E-09	1.060E-09	9.896E-14	9.993E-15
12	.95	1.101E-09	0.	1.101E-09	9.363E-14	8.501E-15
13	.70	9.938E-10	0.	9.938E-10	6.920E-14	6.558E-15
14	.50	9.142E-10	0.	9.142E-10	3.984E-14	5.255E-15
15	.40	6.691E-10	0.	6.691E-10	3.576E-14	3.413E-15
16	.30	7.273E-10	0.	7.273E-10	2.897E-14	2.856E-15
17	.20	7.864E-10	0.	7.864E-10	2.738E-14	2.922E-15
18	.10	4.641E-10	0.	4.641E-10	9.054E-15	1.056E-15
19	.09	9.964E-11	0.	0.	1.775E-15	2.125E-16
20	.08	1.099E-10	0.	0.	1.837E-15	2.122E-16
21	.07	1.224E-10	0.	0.	1.679E-15	2.155E-16
22	.06	1.427E-10	0.	0.	1.629E-15	2.218E-16
23	.05	1.824E-10	0.	0.	1.713E-15	2.451E-16
24	.04	2.589E-10	0.	0.	1.865E-15	2.943E-16
25	.03	4.334E-10	0.	0.	2.211E-15	3.878E-16
26	.02	8.766E-10	0.	0.	2.679E-15	5.607E-16
27	.01	1.103E-09	0.	0.	1.299E-15	3.794E-16
		---------	---------	---------	---------	---------
		1.226E-08	3.271E-09	8.927E-09	6.311E-13	6.973E-14

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

RADS(E)/HR

TABLE 2-6 (Continued)

1	1.00	2.281E-14

		2.281E-14

TABLE 2-6 (Continued)

```
     MSFC SAMPLE PROBLEM - SOURCE DATA FROM NAGS
                         - GEOM. - 75 D. PROP. TANK
                         - MERIDIAN RING COS(A)=1.0 TO 0.9
2-0        50   6    3
6-0        52   2    4    6   8  10  12
2 1        75  29    7
5-0         7  0.              1.00000E+01  2.00000E+01  3.00000E+01  4.00000E+01
2-0        12  5.00000E+01     5.58800E+01
4-0        28  1.39700E+02     1.45000E+02  1.50000E+02  1.54940E+02
2-0         1  1.00000E+00     0.
5 0      1400  1.75331E-02     1.02969E-03  4.78818E-03  4.42958E-03  1.17044E-02
5 0      1405  9.18060E-03     4.08992E-03  7.77896E-03  2.42428E-03  2.13471E-02
3 0      1410  1.68242E-03     6.19382E-04  6.19498E-04
1 0      5533  0.
5 0      5534  3.50000E+00     9.50000E+00  1.40000E+01  1.80000E+01  2.20000E+01
5 0      5539  2.60000E+01     3.00000E+01  3.35000E+01  3.65000E+01  3.90000E+01
5 0      5544  4.10000E+01     4.27500E+01  4.42500E+01  4.55000E+01  4.65000E+01
5 0      5549  4.73750E+01     4.81250E+01  4.87500E+01  4.92500E+01  4.97500E+01
5 0      5554  5.02000E+01     5.06000E+01  5.10500E+01  5.16500E+01  5.25000E+01
2 0      5559  5.37500E+01     5.51900E+01
1 0      5561  5.58800E+01
1 0      5584  1.39700E+02
5 0      5585  1.40300E+02     1.42400E+02  1.45900E+02  1.49900E+02  1.53420E+02
1 0      5590  1.54940E+02
1 0      5635  1.44850E+00
5 0      5636  1.44570E+00     1.42787E+00  1.40158E+00  1.36742E+00  1.32239E+00
5 0      5641  1.26538E+00     1.19562E+00  1.12470E+00  1.05592E+00  9.94441E-01
5 0      5646  9.42695E-01     8.96468E-01  8.56650E-01  8.23799E-01  7.98232E-01
5 0      5651  7.76585E-01     7.58824E-01  7.44581E-01  7.33701E-01  7.23254E-01
5 0      5656  7.14191E-01     7.06389E-01  6.97894E-01  6.87104E-01  6.72632E-01
2 0      5661  6.53882E-01     6.39046E-01
1 0      5663  6.22169E-01
1 0      5686  1.83579E+00
5 0      5687  1.73407E+00     1.49947E+00  1.13770E+00  7.41033E-01  3.76900E-01
1 1      5692  1.53117E-01
          CALCULATED RESULTS FOR SOURCE REGION    1

                       REGION NO.  7 AXIAL SUPPORT PLATE REGION      P1


RECEIVER POINT  A=0.998
COORDINATES R.......     4.08932E+01
```

TABLE 2-6 (Continued)

Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	3.684E-10	3.132E-16	3.795E-16
2	7.25	2.118E-11	1.864E-17	2.224E-17
3	6.50	9.304E-11	8.559E-17	1.005E-16
4	5.50	8.056E-11	3.625E-17	9.345E-17
5	4.50	1.845E-10	1.937E-16	2.232E-16
6	3.50	1.236E-10	1.421E-16	1.619E-16
7	2.80	4.528E-11	5.569E-17	6.384E-17
8	2.50	8.140E-11	1.034E-16	1.180E-16
9	2.00	2.090E-11	2.863E-17	3.260E-17
10	1.50	1.319E-10	1.953E-16	2.230E-16
11	1.00	6.125E-12	9.861E-18	1.127E-17
12	.70	1.525E-12	2.547E-18	2.959E-18
13	.30	4.891E-13	8.120E-19	9.244E-19
		---------	---------	---------
		1.159E-09	1.186E-15	1.433E-15

REGION NO. 7 AXIAL SUPPORT PLATE REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	2.055E-10	1.747E-16	2.117E-16
2	7.25	1.108E-11	9.749E-18	1.163E-17
3	6.50	4.589E-11	4.222E-17	4.957E-17
4	5.50	3.623E-11	1.630E-17	4.203E-17
5	4.50	7.212E-11	7.572E-17	8.726E-17
6	3.50	4.003E-11	4.603E-17	5.244E-17
7	2.80	1.204E-11	1.481E-17	1.698E-17
8	2.50	1.970E-11	2.502E-17	2.857E-17
9	2.00	4.064E-12	5.567E-18	6.339E-18

TABLE 2-6 (Continued)

10	1.50	1.838E-11	2.721E-17	3.107F-17
11	1.00	4.768E-13	7.677E-19	8.773F-19
12	.70	6.240E-14	1.042E-19	1.211F-19
13	.30	3.035E-15	5.037E-21	5.735E-21
		---------	---------	---------
		4.656E-10	4.382E-16	5.385E-16

REGION NO. 7 AXIAL SUPPORT PLATE REGION P1

RECEIVER POINT A=0.998
COORDINATES R....... 4.08932E+01
Z....... 9.82485E+02
PHI..... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	3.424E-12	3.424E-12	3.424E-12	3.965E-16	6.098E-17
2	9.00	8.841E-12	8.841E-12	8.841E-12	9.734E-16	1.492E-16
3	8.00	1.483E-11	1.483E-11	1.483E-11	1.645E-15	2.540E-16
4	7.00	3.071E-11	3.071E-11	3.071E-11	3.280E-15	4.971E-16
5	6.00	7.447E-11	7.447E-11	7.447E-11	7.954E-15	1.206E-15
6	5.00	2.009E-10	2.009E-10	2.009F-10	2.132E-14	3.221E-15
7	4.00	5.726E-10	5.726E-10	5.726E-10	5.955E-14	8.525E-15
8	3.20	7.976E-10	7.976E-10	7.976E-10	7.804E-14	1.098E-14
9	2.50	2.180E-09	2.180E-09	2.180F-09	1.969E-13	2.570E-14
10	1.80	3.231E-09	3.231E-09	3.231E-09	3.106E-13	3.447E-14
11	1.30	3.395E-09	3.395E-09	3.395F-09	3.169E-13	3.200E-14
12	.95	3.369E-09	0.	3.369E-09	2.864E-13	2.601E-14
13	.70	3.078E-09	0.	3.078E-09	2.143E-13	2.031E-14
14	.50	2.822E-09	0.	2.822E-09	1.230E-13	1.622E-14
15	.40	2.045E-09	0.	2.045E-09	1.093E-13	1.043E-14
16	.30	2.197E-09	0.	2.197E-09	8.752E-14	8.629E-15
17	.20	2.335E-09	0.	2.335E-09	8.127E-14	8.676E-15
18	.10	1.349E-09	0.	1.349E-09	2.631E-14	3.068E-15
19	.09	2.920E-10	0.	0.	5.201E-15	6.229E-16
20	.08	3.175E-10	0.	0.	5.308E-15	6.131E-16
21	.07	3.432E-10	0.	0.	4.709E-15	6.044E-16
22	.06	3.858E-10	0.	0.	4.402E-15	5.995E-16
23	.05	4.714E-10	0.	0.	4.427E-15	6.335E-16
24	.04	6.546E-10	0.	0.	4.717E-15	7.443E-16
25	.03	1.080E-09	0.	0.	5.511E-15	9.666E-16

26	.02	2.216E-09	0.	0.	6.771E-15	1.417E-15
27	.01	2.951E-09	0.	0.	3.477E-15	1.016E-15
		---------	---------	---------	---------	---------
		3.641E-08	1.951E-08	2.770E-08	1.970E-12	2.176E-13

REGION NO. 7 AXIAL SUPPORT PLATE REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		RADS(E)/HR
1	1.00	6.666E-14

		6.666E-14

FOR SOURCE REGION 1 AND DETECTOR POINT 1 THERE HAS BEEN 0 AND 0 PATH LENGTH CALCULATIONS
IN EXCESS OF 20.0 MEAN FREE PATHS(GAMMA RAY) AND 120.0 GRAMS/CM**2(NEUTRON),RESPECTIVELY

INTERMEDIATE SUMMARY RESULTS OVER A SUBSET OF SOURCE REGIONS

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	3.684E-10	3.132E-16	3.795E-16
2	7.25	2.118E-11	1.864E-17	2.224E-17

3	6.50	9.304E-11	8.559E-17	1.005E-16
4	5.50	8.056E-11	3.625E-17	9.345E-17
5	4.50	1.845E-10	1.937E-16	2.232E-16
6	3.50	1.236E-10	1.421E-16	1.619E-16
7	2.80	4.528E-11	5.569E-17	6.384E-17
8	2.50	8.140E-11	1.034E-16	1.180E-16
9	2.00	2.090E-11	2.863E-17	3.260E-17
10	1.50	1.319E-10	1.953E-16	2.230E-16
11	1.00	6.125E-12	9.861E-18	1.127E-17
12	.70	1.525E-12	2.547E-18	2.959E-18
13	.30	4.891E-13	8.120E-19	9.244E-19
		---------	---------	---------
		1.159E-09	1.186E-15	1.433E-15

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	2.055E-10	1.747E-16	2.117E-16
2	7.25	1.108E-11	9.749E-18	1.163E-17
3	6.50	4.589E-11	4.222E-17	4.957E-17
4	5.50	3.623E-11	1.630E-17	4.203E-17
5	4.50	7.212E-11	7.572E-17	8.726E-17
6	3.50	4.003E-11	4.603E-17	5.244E-17
7	2.80	1.204E-11	1.481E-17	1.698E-17
8	2.50	1.970E-11	2.502E-17	2.857E-17
9	2.00	4.064E-12	5.567E-18	6.339E-18
10	1.50	1.838E-11	2.721E-17	3.107E-17
11	1.00	4.768E-13	7.677E-19	8.773E-19
12	.70	6.240E-14	1.042E-19	1.211E-19
13	.30	3.035E-15	5.037E-21	5.735E-21
		---------	---------	---------
		4.656E-10	4.382E-16	5.385E-16

EXTRA CORE REGIONS - TOTAL

TABLE 2-6 (Continued)

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI..... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	3.424E-12	3.424E-12	3.424E-12	3.965E-16	6.098E-17
2	9.00	8.841E-12	8.841E-12	8.841E-12	9.734E-16	1.492E-16
3	8.00	1.483E-11	1.483E-11	1.483E-11	1.645E-15	2.540E-16
4	7.00	3.071E-11	3.071E-11	3.071E-11	3.280E-15	4.971E-16
5	6.00	7.447E-11	7.447E-11	7.447E-11	7.954E-15	1.206E-15
6	5.00	2.009E-10	2.009E-10	2.009E-10	2.132E-14	3.22[illegible]E-15
7	4.00	5.726E-10	5.726E-10	5.726E-10	5.955E-14	8.525E-15
8	3.20	7.976E-10	7.976E-10	7.976E-10	7.804E-14	1.098E-14
9	2.50	2.180E-09	2.180E-09	2.180E-09	1.969E-13	2.570E-14
10	1.80	3.231E-09	3.231E-09	3.231E-09	3.106E-13	3.447E-14
11	1.30	3.395E-09	3.395E-09	3.395E-09	3.169E-13	3.200E-14
12	.95	3.369E-09	0.	3.369E-09	2.864E-13	2.601E-14
13	.70	3.078E-09	0.	3.078E-09	2.143E-13	2.031E-14
14	.50	2.822E-09	0.	2.822E-09	1.230E-13	1.622E-14
15	.40	2.045E-09	0.	2.045E-09	1.093E-13	1.043E-14
16	.30	2.197E-09	0.	2.197E-09	8.752E-14	8.629E-15
17	.20	2.335E-09	0.	2.335E-09	8.127E-14	8.676E-15
18	.10	1.349E-09	0.	1.349E-09	2.631E-14	3.068E-15
19	.09	2.920E-10	0.	0.	5.201E-15	6.229E-16
20	.08	3.175E-10	0.	0.	5.308E-15	6.131E-16
21	.07	3.432E-10	0.	0.	4.709E-15	6.044E-16
22	.06	3.858E-10	0.	0.	4.402E-15	5.995E-16
23	.05	4.714E-10	0.	0.	4.427E-15	6.335E-16
24	.04	6.546E-10	0.	0.	4.717E-15	7.443E-16
25	.03	1.080E-09	0.	0.	5.511E-15	9.666E-16
26	.02	2.216E-09	0.	0.	6.771E-15	1.417E-15
27	.01	2.951E-09	0.	0.	3.477E-15	1.016E-15
		---------	---------	---------	---------	---------
		3.641E-08	1.951E-08	2.770E-08	1.970E-12	2.176E-13

EXTRA CORE REGIONS - TOTAL

Astronuclear Laboratory

TABLE 2-6 (Continued)

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RECEIVER POINT  A=0.998
COORDINATES R.......    4.08932E+01
            Z.......    9.82485E+02
            PHI.....    0.

         RADS(E)/HR

1  1.00   6.666E-14
          ---------
          6.666E-14
```

TABLE 2-6 (Continued)

```
      MSFC SAMPLE PROBLEM - SOURCE DATA FROM NAGS
                          - GEOM. - 75 D. PROP. TANK
                          - MERIDIAN RING COS(A)=1.0 TO 0.9
2-0          50   8  12
8-0          52   2   4   6   8  10  12  14  16
2 1          75  34  41
5-0           7  0.              1.00000E+01  2.00000E+01  3.00000E+01  4.00000E+01
4-0          12  5.00000E+01  5.50000E+01  6.00000E+01  6.35000E+01
5-0          28  1.54940E+02  1.55500E+02  1.58000E+02  1.62000E+02  1.66000E+02
5-0          33  1.70000E+02  1.74000E+02  1.78000E+02  1.82000E+02  1.82000E+02
3-0          38  1.86000E+02  1.90000E+02  1.93040E+02
2-0           1  1.00000E+00  0.
5 0        1400  1.00346E-04  2.47759E-05  1.02079E-03  9.53349E-05  2.39458E-04
5 0        1405  2.11365E-04  7.39501E-05  1.52885E-04  8.92423E-05  5.07486E-04
3 0        1410  2.33734E-04  6.78779E-03  2.52332E-05
1 0        5533  0.
5 0        5534  3.50000E+00  9.50000E+00  1.40000E+01  1.80000E+01  2.20000E+01
5 0        5539  2.60000E+01  3.00000E+01  3.35000E+01  3.65000E+01  3.90000E+01
5 0        5544  4.10000E+01  4.27500E+01  4.42500E+01  4.55000E+01  4.65000E+01
5 0        5549  4.73750E+01  4.81250E+01  4.87500E+01  4.92500E+01  4.97500E+01
5 0        5554  5.02000E+01  5.06000E+01  5.10500E+01  5.16500E+01  5.25000E+01
5 0        5559  5.37500E+01  5.51900E+01  5.66900E+01  5.82500E+01  5.97500E+01
2 0        5564  6.12500E+01  6.27500E+01
1 0        5566  6.35000E+01
1 0        5584  1.54940E+02
5 0        5585  1.55005E+02  1.55135E+02  1.55265E+02  1.55395E+02  1.55525E+02
5 0        5590  1.55655E+02  1.55785E+02  1.55945E+02  1.56240E+02  1.56740E+02
5 0        5595  1.57590E+02  1.58690E+02  1.59990E+02  1.61490E+02  1.62990E+02
5 0        5600  1.64490E+02  1.66240E+02  1.68240E+02  1.70240E+02  1.72240E+02
5 0        5605  1.74240E+02  1.76240E+02  1.78240E+02  1.80240E+02  1.82240E+02
5 0        5610  1.84240E+02  1.85990E+02  1.87490E+02  1.88740E+02  1.89740E+02
5 0        5615  1.90590E+02  1.91290E+02  1.91840E+02  1.92140E+02  1.92340E+02
4 0        5620  1.92540E+02  1.92740E+02  1.92890E+02  1.92990E+02
1 0        5624  1.93040E+02
1 0        5635  1.88251E+00
5 0        5636  1.87897E+00  1.85648E+00  1.82321E+00  1.77949E+00  1.72075E+00
5 0        5641  1.64457E+00  1.54835E+00  1.44765E+00  1.34669E+00  1.25443E+00
5 0        5646  1.17477E+00  1.10319E+00  1.04095E+00  9.90366E-01  9.48246E-01
5 0        5651  9.11869E-01  8.80361E-01  8.54252E-01  8.34032E-01  8.13985E-01
5 0        5656  7.95386E-01  7.78501E-01  7.60273E-01  7.34441E-01  6.99936E-01
5 0        5661  6.43647E-01  5.47494E-01  3.86348E-01  2.51898E-01  1.90384E-01
2 0        5666  1.25842E-01  7.83726E-02
1 0        5668  1.31610E-01
1 0        5686  9.32069E+01
5 0        5687  8.62197E+01  3.71349E+01  2.11022E+01  1.39236E+01  1.01375E+01
5 0        5692  7.87185E+00  6.47857E+00  5.38330E+00  4.21171E+00  3.10859E+00
5 0        5697  2.19419E+00  1.50614E+00  1.06032E+00  7.28674E-01  5.17388E-01
```

TABLE 2-6 (Continued)

5	0	5702	3.74946E-01	2.64407E-01	1.77988E-01	1.21353E-01	8.34209E-02
5	0	5707	5.76306E-02	3.99416E-02	2.77393E-02	1.92958E-02	1.34201E-02
5	0	5712	9.33034E-03	6.75556E-03	5.12660E-03	4.05234E-03	3.34674E-03
5	0	5717	2.85381E-03	2.52232E-03	2.34345E-03	2.30111E-03	2.33776E-03
4	0	5722	2.49615E-03	3.07863E-03	4.12893E-03	6.51415E-03	
1	1	5726	6.65559E-03				

CALCULATED RESULTS FOR SOURCE REGION 1

REGION NO. 8 AXIAL BATH SHIELD REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	2.404E-12	2.043E-18	2.476E-18
2	7.25	5.826E-13	5.127E-19	6.118E-19
3	6.50	2.280E-11	2.098E-17	2.463E-17
4	5.50	2.007E-12	9.034E-19	2.329E-18
5	4.50	4.433E-12	4.654E-18	5.364E-18
6	3.50	3.402E-12	3.913E-18	4.457E-18
7	2.80	1.001E-12	1.232E-18	1.412E-18
8	2.50	1.973E-12	2.506E-18	2.861E-18
9	2.00	9.725E-13	1.332E-18	1.517E-18
10	1.50	4.141E-12	6.129E-18	6.998E-18
11	1.00	1.214E-12	1.955E-18	2.235E-18
12	.70	2.578E-11	4.305E-17	5.001E-17
13	.30	4.487E-14	7.448E-20	8.480E-20
		---------	---------	---------
		7.076E-11	8.928E-17	1.050E-16

REGION NO. 8 AXIAL BATH SHIELD REGION P1

TABLE 2-6 (Continued)

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	1.383E-12	1.176E-18	1.425E-18
2	7.25	3.156E-13	2.777E-19	3.314E-19
3	6.50	1.168E-11	1.075E-17	1.262E-17
4	5.50	9.428E-13	4.243E-19	1.094E-18
5	4.50	1.825E-12	1.917E-18	2.209E-18
6	3.50	1.175E-12	1.351E-18	1.539E-18
7	2.80	2.882E-13	3.544E-19	4.063E-19
8	2.50	5.205E-13	6.611E-19	7.548E-19
9	2.00	2.104E-13	2.883E-19	3.282E-19
10	1.50	6.691E-13	9.902E-19	1.131E-18
11	1.00	1.221E-13	1.966E-19	2.247E-19
12	.70	1.608E-12	2.685E-18	3.119E-18
13	.30	1.057E-15	1.754E-21	1.998E-21
		---------	---------	---------
		2.075E-11	2.107E-17	2.518E-17

REGION NO. 8 AXIAL BATH SHIELD REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	4.655E-12	4.655E-12	4.655E-12	5.390E-16	8.290E-17
2	9.00	1.268E-11	1.268E-11	1.268E-11	1.396E-15	2.140E-16
3	8.00	2.215E-11	2.215E-11	2.215E-11	2.456E-15	3.792E-16
4	7.00	4.706E-11	4.706E-11	4.706E-11	5.026E-15	7.618E-16
5	6.00	1.155E-10	1.155E-10	1.155E-10	1.234E-14	1.870E-15
6	5.00	3.120E-10	3.120E-10	3.120E-10	3.311E-14	5.002E-15
7	4.00	8.835E-10	8.835E-10	8.835E-10	9.188E-14	1.315E-14

TABLE 2-6 (Continued)

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI..... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	2.404E-12	2.043E-18	2.476E-18
2	7.25	5.826E-13	5.127E-19	6.118E-19
3	6.50	2.280E-11	2.098E-17	2.463E-17
4	5.50	2.007E-12	9.034E-19	2.329E-18
5	4.50	4.433E-12	4.654E-18	5.364E-18
6	3.50	3.402E-12	3.913E-18	4.457E-18
7	2.80	1.001E-12	1.232E-18	1.412E-18
8	2.50	1.973E-12	2.506E-18	2.861E-18
9	2.00	9.725E-13	1.332E-18	1.517E-18
10	1.50	4.141E-12	6.129E-18	6.998E-18
11	1.00	1.214E-12	1.955E-18	2.235E-18
12	.70	2.578E-11	4.305E-17	5.001E-17
13	.30	4.487E-14	7.448E-20	8.480E-20
		---------	---------	---------
		7.076E-11	8.928E-17	1.050E-16

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI..... 0.

MEV/CM2-SEC RADS(C)/HR REM/HR

TABLE 2-6 (Continued)

8	3.20	1.220E-09	1.220E-09	1.220E-09	1.194E-13	1.679E-14
9	2.50	3.306E-09	3.306E-09	3.306E-09	2.986E-13	3.898E-14
10	1.80	4.854E-09	4.854E-09	4.854E-09	4.667E-13	5.179E-14
11	1.30	5.068E-09	5.068E-09	5.068E-09	4.730E-13	4.776E-14
12	.95	5.228E-09	0.	5.228E-09	4.445E-13	4.036E-14
13	.70	4.676E-09	0.	4.676E-09	3.256E-13	3.086E-14
14	.50	4.291E-09	0.	4.291E-09	1.870E-13	2.467E-14
15	.40	3.129E-09	0.	3.129E-09	1.672E-13	1.596E-14
16	.30	3.398E-09	0.	3.398E-09	1.353E-13	1.334E-14
17	.20	3.664E-09	0.	3.664E-09	1.275E-13	1.361E-14
18	.10	2.157E-09	0.	2.157E-09	4.209E-14	4.908E-15
19	.09	4.713E-10	0.	0.	8.393E-15	1.005E-15
20	.08	5.140E-10	0.	0.	8.593E-15	9.925E-16
21	.07	5.562E-10	0.	0.	7.631E-15	9.795E-16
22	.06	6.242E-10	0.	0.	7.122E-15	9.700E-16
23	.05	7.590E-10	0.	0.	7.129E-15	1.020E-15
24	.04	1.045E-09	0.	0.	7.529E-15	1.188E-15
25	.03	1.702E-09	0.	0.	8.682E-15	1.523E-15
26	.02	3.432E-09	0.	0.	1.049E-14	2.195E-15
27	.01	4.486E-09	0.	0.	5.285E-15	1.544E-15
		---------	---------	---------	---------	---------
		5.598E-08	1.585E-08	4.239E-08	3.005E-12	3.319E-13

REGION NO. 8 AXIAL BATH SHIELD REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

RADS(E)/HR

1	1.00	1.036E-13

		1.036E-13

FOR SOURCE REGION 1 AND DETECTOR POINT 1 THERE HAS BEEN 0 AND 0 PATH LENGTH CALCULATIONS
IN EXCESS OF 20.0 MEAN FREE PATHS(GAMMA RAY) AND 120.0 GRAMS/CM**2(NEUTRON).RESPECTIVELY

INTERMEDIATE SUMMARY RESULTS OVER A SUBSET OF SOURCE REGIONS

TABLE 2-6 (Continued)

1	8.50	1.383E-12	1.176E-18	1.425E-18
2	7.25	3.156E-13	2.777E-19	3.314E-19
3	6.50	1.168E-11	1.075E-17	1.262E-17
4	5.50	9.428E-13	4.243E-19	1.094E-18
5	4.50	1.825E-12	1.917E-18	2.209E-18
6	3.50	1.175E-12	1.351E-18	1.539E-18
7	2.80	2.882E-13	3.544E-19	4.063E-19
8	2.50	5.205E-13	6.611E-19	7.548E-19
9	2.00	2.104E-13	2.883E-19	3.282E-19
10	1.50	6.691E-13	9.902E-19	1.131E-18
11	1.00	1.221E-13	1.966E-19	2.247E-19
12	.70	1.608E-12	2.685E-18	3.119E-18
13	.30	1.057E-15	1.754E-21	1.998E-21
		---------	---------	---------
		2.075E-11	2.107E-17	2.518E-17

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R....... 4.08932E+01
Z....... 9.82485E+02
PHI..... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	4.655E-12	4.655E-12	4.655E-12	5.390E-16	8.290E-17
2	9.00	1.268E-11	1.268E-11	1.268E-11	1.396E-15	2.140E-16
3	8.00	2.215E-11	2.215E-11	2.215E-11	2.456E-15	3.792E-16
4	7.00	4.706E-11	4.706E-11	4.706E-11	5.026E-15	7.618E-16
5	6.00	1.155E-10	1.155E-10	1.155E-10	1.234E-14	1.870E-15
6	5.00	3.120E-10	3.120E-10	3.120E-10	3.311E-14	5.002E-15
7	4.00	8.835E-10	8.835E-10	8.835E-10	9.188E-14	1.315E-14
8	3.20	1.220E-09	1.220E-09	1.220E-09	1.194E-13	1.679E-14
9	2.50	3.306E-09	3.306E-09	3.306E-09	2.986E-13	3.898E-14
10	1.80	4.854E-09	4.854E-09	4.854E-09	4.667E-13	5.179E-14
11	1.30	5.068E-09	5.068E-09	5.068E-09	4.730E-13	4.776E-14
12	.95	5.228E-09	0.	5.228E-09	4.445E-13	4.036E-14
13	.70	4.676E-09	0.	4.676E-09	3.256E-13	3.086E-14
14	.50	4.291E-09	0.	4.291E-09	1.870E-13	2.467E-14
15	.40	3.129E-09	0.	3.129E-09	1.672E-13	1.596E-14
16	.30	3.398E-09	0.	3.398E-09	1.353E-13	1.334E-14

TABLE 2-6 (Continued)

17	.20	3.664E-09	0.	3.664E-09	1.275E-13	1.361E-14
18	.10	2.157E-09	0.	2.157E-09	4.209E-14	4.908E-15
19	.09	4.713E-10	0.	0.	8.393E-15	1.005E-15
20	.08	5.140E-10	0.	0.	8.593E-15	9.925E-16
21	.07	5.562E-10	0.	0.	7.631E-15	9.795E-16
22	.06	6.242E-10	0.	0.	7.122E-15	9.700E-16
23	.05	7.590E-10	0.	0.	7.129E-15	1.020E-15
24	.04	1.045E-09	0.	0.	7.529E-15	1.188E-15
25	.03	1.702E-09	0.	0.	8.682E-15	1.523E-15
26	.02	3.432E-09	0.	0.	1.049E-14	2.195E-15
27	.01	4.486E-09	0.	0.	5.285E-15	1.544E-15
		---------	---------	---------	---------	---------
		5.598E-08	1.585E-08	4.239E-08	3.005E-12	3.319E-13

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

RADS(E)/HR

1	1.00	1.036E-13

		1.036E-13

TABLE 2-6 (Continued)

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MSFC SAMPLE PROBLEM - SOURCE DATA FROM NAGS
                    - GEOM. - 75 D. PROP. TANK
                    - MERIDIAN RING COS(A)=1.0 TO 0.9
2-0     50  7   4
7-0     52  2   4   6   8  10  12  14
2 1     75  34  6
5-0      7  0.            1.00000E+01   2.00000E+01   3.00000E+01   4.00000E+01
3-0     12  5.00000E+01   6.00000E+01   6.35000E+01
5-0     28  1.93040E+02   1.98000E+02   2.04000E+02   2.10000E+02   2.15900E+02
2-0      1  1.00000E+00   0.
5 0   1400  0.            0.            0.            0.            0.
5 0   1405  0.            0.            1.81855E-07   0.            0.
3 0   1410  0.            0.            0.
1 0   5533  0.
5 0   5534  3.50000E+00   9.50000E+00   1.40000E+01   1.80000E+01   2.20000E+01
5 0   5539  2.60000E+01   3.00000E+01   3.35000E+01   3.65000E+01   3.90000E+01
5 0   5544  4.10000E+01   4.27500E+01   4.42500E+01   4.55000E+01   4.65000E+01
5 0   5549  4.73750E+01   4.81250E+01   4.87500E+01   4.92500E+01   4.97500E+01
5 0   5554  5.02000E+01   5.06000E+01   5.10500E+01   5.16500E+01   5.25000E+01
5 0   5559  5.37500E+01   5.51900E+01   5.66900E+01   5.82500E+01   5.97500E+01
2 0   5564  6.12500E+01   6.27500E+01
1 0   5566  6.35000E+01
1 0   5584  1.93040E+02
4 0   5585  1.95520E+02   2.01000E+02   2.07000E+02   2.12950E+02
1 0   5589  2.15900E+02
1 0   5635  1.96572E+00
5 0   5636  1.95931E+00   1.91849E+00   1.86121E+00   1.79157E+00   1.70611E+00
5 0   5641  1.60574E+00   1.49156E+00   1.38192E+00   1.28041E+00   1.19173E+00
5 0   5646  1.11778E+00   1.05135E+00   9.93031E-01   9.43646E-01   9.03535E-01
5 0   5651  8.68084E-01   8.37397E-01   8.11651E-01   7.90919E-01   7.70080E-01
5 0   5656  7.51240E-01   7.34417E-01   7.15416E-01   6.89946E-01   6.53614E-01
5 0   5661  5.99682E-01   5.36916E-01   4.70655E-01   4.00753E-01   3.32098E-01
2 0   5666  2.61146E-01   1.85666E-01
1 0   5668  1.55962E-01
1 0   5686  3.54431E-01
4 0   5687  7.85373E-01   1.21977E+00   1.20350E+00   7.49981E-01
1 1   5691  4.53204E-01

        CALCULATED RESULTS FOR SOURCE REGION   1

              REGION NO. 9 AXIAL DOME PLENUM REGION        P1
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TABLE 2-6 (Continued)

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	0.	0.	0.
2	7.25	0.	0.	0.
3	6.50	0.	0.	0.
4	5.50	0.	0.	0.
5	4.50	0.	0.	0.
6	3.50	0.	0.	0.
7	2.80	0.	0.	0.
8	2.50	2.165E-14	2.750E-20	3.140E-20
9	2.00	0.	0.	0.
10	1.50	0.	0.	0.
11	1.00	0.	0.	0.
12	.70	0.	0.	0.
13	.30	0.	0.	0.
		---------	---------	---------
		2.165E-14	2.750E-20	3.140E-20

REGION NO. 9 AXIAL DOME PLENUM REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	0.	0.	0.
2	7.25	0.	0.	0.
3	6.50	0.	0.	0.
4	5.50	0.	0.	0.
5	4.50	0.	0.	0.
6	3.50	0.	0.	0.
7	2.80	0.	0.	0.

TABLE 2-6 (Continued)

8	2.50	1.781E-14	2.262E-20	2.582E-20
9	2.00	0.	0.	0.
10	1.50	0.	0.	0.
11	1.00	0.	0.	0.
12	.70	0.	0.	0.
13	.30	0.	0.	0.
		---------	---------	---------
		1.781E-14	2.262E-20	2.582E-20

REGION NO. 9 AXIAL DOME PLENUM REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	1.175E-10	1.175E-10	1.175E-10	1.361E-14	2.093E-15
2	9.00	5.140E-10	5.140E-10	5.140E-10	5.659E-14	8.676E-15
3	8.00	1.147E-09	1.147E-09	1.147E-09	1.272E-13	1.964E-14
4	7.00	2.598E-09	2.598E-09	2.598E-09	2.775E-13	4.206E-14
5	6.00	5.926E-09	5.926E-09	5.926E-09	6.329E-13	9.595E-14
6	5.00	1.353E-08	1.353E-08	1.353E-08	1.436E-12	2.169E-13
7	4.00	3.072E-08	3.072E-08	3.072E-08	3.194E-12	4.574E-13
8	3.20	3.521E-08	3.521E-08	3.521E-08	3.445E-12	4.844E-13
9	2.50	8.194E-08	8.194E-08	8.194E-08	7.402E-12	9.661E-13
10	1.80	1.061E-07	1.061E-07	1.061E-07	1.020E-11	1.132E-12
11	1.30	1.037E-07	1.037E-07	1.037E-07	9.683E-12	9.778E-13
12	.95	9.011E-08	0.	9.011E-08	7.661E-12	6.955E-13
13	.70	7.112E-08	0.	7.112E-08	4.952E-12	4.693E-13
14	.50	6.036E-08	0.	6.036E-08	2.630E-12	3.469E-13
15	.40	4.264E-08	0.	4.264E-08	2.279E-12	2.175E-13
16	.30	4.508E-08	0.	4.508E-08	1.795E-12	1.770E-13
17	.20	4.753E-08	0.	4.753E-08	1.655E-12	1.766E-13
18	.10	2.749E-08	0.	2.749E-08	5.363E-13	6.254E-14
19	.09	5.648E-09	0.	0.	1.006E-13	1.205E-14
20	.08	6.218E-09	0.	0.	1.040E-13	1.201E-14
21	.07	7.192E-09	0.	0.	9.868E-14	1.267E-14
22	.06	8.729E-09	0.	0.	9.960E-14	1.356E-14
23	.05	1.110E-08	0.	0.	1.042E-13	1.492E-14

24	.04	1.476E-08	0.	0.	1.063E-13	1.678E-14
25	.03	2.050E-08	0.	0.	1.045E-13	1.834E-14
26	.02	2.968E-08	0.	0.	9.071E-14	1.899E-14
27	.01	2.238E-08	0.	0.	2.637E-14	7.702E-15
		---------	---------	---------	---------	---------
		8.921E-07	3.816E-07	7.659E-07	5.881E-11	6.676E-12

REGION NO. 9 AXIAL DOME PLENUM REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

RADS(E)/HR

1	1.00	3.329E-12

		3.329E-12

FOR SOURCE REGION 1 AND DETECTOR POINT 1 THERE HAS BEEN 0 AND 0 PATH LENGTH CALCULATIONS IN EXCESS OF 20.0 MEAN FREE PATHS(GAMMA RAY) AND 120.0 GRAMS/CM**2(NEUTRON),RESPECTIVELY

INTERMEDIATE SUMMARY RESULTS OVER A SUBSET OF SOURCE REGIONS

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

MEV/CM2-SEC RADS(C)/HR REM/HR

TABLE 2-6 (Continued)

1	8.50	0.	0.	0.
2	7.25	0.	0.	0.
3	6.50	0.	0.	0.
4	5.50	0.	0.	0.
5	4.50	0.	0.	0.
6	3.50	0.	0.	0.
7	2.80	0.	0.	0.
8	2.50	2.165E-14	2.750E-20	3.140E-20
9	2.00	0.	0.	0.
10	1.50	0.	0.	0.
11	1.00	0.	0.	0.
12	.70	0.	0.	0.
13	.30	0.	0.	0.
		---------	---------	---------
		2.165E-14	2.750E-20	3.140E-20

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	0.	0.	0.
2	7.25	0.	0.	0.
3	6.50	0.	0.	0.
4	5.50	0.	0.	0.
5	4.50	0.	0.	0.
6	3.50	0.	0.	0.
7	2.80	0.	0.	0.
8	2.50	1.781E-14	2.262E-20	2.582E-20
9	2.00	0.	0.	0.
10	1.50	0.	0.	0.
11	1.00	0.	0.	0.
12	.70	0.	0.	0.
13	.30	0.	0.	0.
		---------	---------	---------
		1.781E-14	2.262E-20	2.582E-20

TABLE 2-6 (Continued)

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI..... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	1.175E-10	1.175E-[illegible]	1.175E-10	1.361E-14	2.093E-15
2	9.00	5.140E-10	5.140E-10	5.140E-10	5.659E-14	8.676E-15
3	8.00	1.147E-09	1.147E-09	1.147E-09	1.272E-13	1.964E-14
4	7.00	2.598E-09	2.598E-09	2.598E-09	2.775E-13	4.206E-14
5	6.00	5.926E-09	5.926E-09	5.926E-09	6.329E-13	9.595E-14
6	5.00	1.353E-08	1.353E-08	1.353E-08	1.436E-12	2.169E-13
7	4.00	3.072E-08	3.072E-08	3.072E-08	3.194E-12	4.574E-13
8	3.20	3.521E-08	3.521E-08	3.521E-08	3.445E-12	4.844E-13
9	2.50	8.194E-08	8.194E-08	8.194E-08	7.402E-12	9.661E-13
10	1.80	1.061E-07	1.061E-07	1.061E-07	1.020E-11	1.132E-12
11	1.30	1.037E-07	1.037E-07	1.037E-07	9.683E-12	9.778E-13
12	.95	9.011E-08	0.	9.011E-08	7.661E-12	6.955E-13
13	.70	7.112E-08	0.	7.112E-08	4.952E-12	4.693E-13
14	.50	6.036E-08	0.	6.036E-08	2.630E-12	3.469E-13
15	.40	4.264E-08	0.	4.264E-08	2.279E-12	2.175E-13
16	.30	4.508E-08	0.	4.508E-08	1.795E-12	1.770E-13
17	.20	4.753E-08	0.	4.753E-08	1.655E-12	1.766E-13
18	.10	2.749E-08	0.	2.749E-08	5.363E-13	6.254E-14
19	.09	5.648E-09	0.	0.	1.006E-13	1.205E-14
20	.08	6.218E-09	0.	0.	1.040E-13	1.201E-14
21	.07	7.192E-09	0.	0.	9.868E-14	1.267E-14
22	.06	8.729E-09	0.	0.	9.960E-14	1.356E-14
23	.05	1.110E-08	0.	0.	1.042E-13	1.492E-14
24	.04	1.476E-08	0.	0.	1.063E-13	1.678E-14
25	.03	2.050E-08	0.	0.	1.045E-13	1.834E-14
26	.02	2.968E-08	0.	0.	9.071E-14	1.899E-14
27	.01	2.238E-08	0.	0.	2.637E-14	7.702E-15
		---------	---------	---------	---------	---------
		8.921E-07	3.816E-07	7.659E-07	5.881E-11	6.676E-12

EXTRA CORE REGIONS - TOTAL

TABLE 2-6 (Continued)

```
RECEIVER POINT  A=0.998
COORDINATES R......     4.08932E+01
            Z......     9.82485E+02
            PHI....     0.

          RADS(E)/HR

1  1.00    3.329E-12
           ---------
           3.329E-12
```

TABLE 2-6 (Continued)

MSFC SAMPLE PROBLEM - SOURCE DATA FROM NAGS
- GEOM. - 75 D. PROP. TANK
- MERIDIAN RING COS(A)=1.0 TO 0.9

1-0	31	3						
2-0	50	7	2					
7-0	52	2	4	6	8	10	12	14
2 1	75	36	4					
5-0	7	0.	1.00000E+01	2.00000E+01	3.00000E+01	4.00000E+01		
3-0	12	5.00000E+01	6.00000E+01	6.64000E+01				
3-0	28	2.15900E+02	2.17000E+02	2.18440E+02				
2-0	1	1.00000E+00	0.					
5 0	1400	4.19149E-08	4.01930E-09	1.93538E-08	2.28532E-08	4.19199E-08		
5 0	1405	3.42619E-08	1.88453E-08	3.02880E-08	2.57185E-08	6.45205E-08		
3 0	1410	2.49050E-08	6.16882E-09	2.48045E-09				
1 0	5533	0.						
5 0	5534	3.50000E+00	9.50000E+00	1.40000E+01	1.80000E+01	2.20000E+01		
5 0	5539	2.60000E+01	3.00000E+01	3.35000E+01	3.65000E+01	3.90000E+01		
5 0	5544	4.10000E+01	4.27500E+01	4.42500E+01	4.55000E+01	4.65000E+01		
5 0	5549	4.73750E+01	4.81250E+01	4.87500E+01	4.92500E+01	4.97500E+01		
5 0	5554	5.02000E+01	5.06000E+01	5.10500E+01	5.16500E+01	5.25000E+01		
5 0	5559	5.37500E+01	5.51900E+01	5.66900E+01	5.82500E+01	5.97500E+01		
4 0	5564	6.12500E+01	6.27500E+01	6.42500E+01	6.55200E+01			
1 0	5568	6.60400E+01						
1 0	5584	2.15900E+02						
2 0	5585	2.16700E+02	2.17970E+02					
1 0	5587	2.18440E+02						
1 0	5635	1.90907E+00						
5 0	5636	1.90522E+00	1.88068E+00	1.80723E+00	1.72030E+00	1.63560E+00		
5 0	5641	1.54594E+00	1.43899E+00	1.34613E+00	1.27038E+00	1.20327E+00		
5 0	5646	1.13896E+00	1.07788E+00	1.03052E+00	9.94195E-01	9.68858E-01		
5 0	5651	9.40465E-01	9.04511E-01	8.78416E-01	8.71588E-01	8.69175E-01		
5 0	5656	8.61230E-01	8.32337E-01	7.92539E-01	7.64717E-01	7.42075E-01		
5 0	5661	7.23916E-01	6.63804E-01	5.94387E-01	6.07213E-01	5.33745E-01		
4 0	5666	4.32941E-01	4.38821E-01	3.88121E-01	2.68616E-01			
1 0	5670	2.31065E-01						
1 0	5686	1.20938E+00						
2 0	5687	1.07954E+00	8.64614E-01					
1 1	5689	7.96418E-01						

CALCULATED RESULTS FOR SOURCE REGION 1

REGION NO. 10 AXIAL PRESSURE VESSEL REGION P1

TABLE 2-6 (Continued)

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	5.375E-15	4.569E-21	5.537E-21
2	7.25	5.156E-16	4.537E-22	5.414E-22
3	6.50	2.481E-15	2.282E-21	2.679E-21
4	5.50	2.929E-15	1.318E-21	3.398E-21
5	4.50	5.369E-15	5.637E-21	6.496E-21
6	3.50	4.396E-15	5.056E-21	5.759E-21
7	2.80	2.425E-15	2.983E-21	3.419E-21
8	2.50	3.910E-15	4.965E-21	5.669E-21
9	2.00	3.339E-15	4.575E-21	5.210E-21
10	1.50	8.447E-15	1.250E-20	1.427E-20
11	1.00	3.286E-15	5.291E-21	6.047E-21
12	.70	8.134E-16	1.358E-21	1.578E-21
13	.30	3.766E-16	6.251E-22	7.117E-22
		---------	---------	---------
		4.366E-14	5.161E-20	6.132E-20

REGION NO. 10 AXIAL PRESSURE VESSEL REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	5.188E-15	4.410E-21	5.344E-21
2	7.25	4.960E-16	4.365E-22	5.208E-22
3	6.50	2.378E-15	2.188E-21	2.568E-21
4	5.50	2.792E-15	1.256E-21	3.238E-21
5	4.50	5.066E-15	5.320E-21	6.130E-21
6	3.50	4.088E-15	4.702E-21	5.356E-21

TABLE 2-6 (Continued)

7	2.80	2.216E-15	2.726E-21	3.125E-21
8	2.50	3.542E-15	4.499E-21	5.137E-21
9	2.00	2.963E-15	4.059E-21	4.622E-21
10	1.50	7.252E-15	1.073E-20	1.226E-20
11	1.00	2.687E-15	4.327E-21	4.945E-21
12	.70	6.411E-16	1.071E-21	1.244E-21
13	.30	2.314E-16	3.841E-22	4.374E-22
		---------	---------	---------
		3.954E-14	4.611E-20	5.492E-20

REGION NO. 10 AXIAL PRESSURE VESSEL REGION P1

RECEIVER POINT A=0.998
COORDINATES R....... 4.08932E+01
Z....... 9.82485E+02
PHI..... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	1.474E-10	1.474E-10	1.474E-10	1.707E-14	2.626E-15
2	9.00	6.680E-10	6.680E-10	6.680E-10	7.355E-14	1.128E-14
3	8.00	1.512E-09	1.512E-09	1.512E-09	1.676E-13	2.588E-14
4	7.00	3.409E-09	3.409E-09	3.409E-09	3.641E-13	5.519E-14
5	6.00	7.647E-09	7.647E-09	7.647E-09	8.167E-13	1.238E-13
6	5.00	1.703E-08	1.703E-08	1.703E-08	1.807E-12	2.730E-13
7	4.00	3.759E-08	3.759E-08	3.759E-08	3.909E-12	5.597E-13
8	3.20	4.215E-08	4.215E-08	4.215E-08	4.124E-12	5.800E-13
9	2.50	9.651E-08	9.651E-08	9.651E-08	8.718E-12	1.138E-12
10	1.80	1.234E-07	1.234E-07	1.234E-07	1.187E-11	1.317E-12
11	1.30	1.200E-07	1.200E-07	1.200E-07	1.120E-11	1.131E-12
12	.95	9.326E-08	0.	9.326E-08	7.929E-12	7.199E-13
13	.70	7.447E-08	0.	7.447E-08	5.185E-12	4.914E-13
14	.50	6.202E-08	0.	6.202E-08	2.703E-12	3.565E-13
15	.40	4.301E-08	0.	4.301E-08	2.298E-12	2.194E-13
16	.30	4.434E-08	0.	4.434E-08	1.766E-12	1.741E-13
17	.20	4.532E-08	0.	4.532E-08	1.578E-12	1.684E-13
18	.10	2.525E-08	0.	2.525E-08	4.926E-13	5.745E-14
19	.09	5.083E-09	0.	0.	9.053E-14	1.084E-14
20	.08	5.557E-09	0.	0.	9.292E-14	1.073E-14
21	.07	6.448E-09	0.	0.	8.847E-14	1.136E-14
22	.06	7.881E-09	0.	0.	8.992E-14	1.225E-14

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TABLE 2-6 (Continued)

23	.05	1.007E-08	0.	0.	9.457E-14	1.353E-14
24	.04	1.335E-08	0.	0.	9.617E-14	1.517E-14
25	.03	1.822E-08	0.	0.	9.292E-14	1.630E-14
26	.02	2.541E-08	0.	0.	7.765E-14	1.625E-14
27	.01	1.798E-08	0.	0.	2.118E-14	6.187E-15
		---------	---------	---------	---------	---------
		9.478E-07	4.501E-07	8.378E-07	6.577E-11	7.517E-12

REGION NO. 10 AXIAL PRESSURE VESSEL REGION P1

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

RADS(E)/HR

1	1.00	4.246E-12

		4.246E-12

FOR SOURCE REGION 1 AND DETECTOR POINT 1 THERE HAS BEEN 0 AND 0 PATH LENGTH CALCULATIONS
IN EXCESS OF 20.0 MEAN FREE PATHS(GAMMA RAY) AND 120.0 GRAMS/CM**2(NEUTRON),RESPECTIVELY

INTERMEDIATE SUMMARY RESULTS OVER A SUBSET OF SOURCE REGIONS

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

MEV/CM2-SEC RADS(C)/HR REM/HR

1	8.50	5.375E-15	4.569E-21	5.537E-21
2	7.25	5.156E-16	4.537E-22	5.414E-22
3	6.50	2.481E-15	2.282E-21	2.679E-21
4	5.50	2.929E-15	1.318E-21	3.398E-21
5	4.50	5.369E-15	5.637E-21	6.496E-21
6	3.50	4.396E-15	5.056E-21	5.759E-21
7	2.80	2.425E-15	2.983E-21	3.419E-21
8	2.50	3.910E-15	4.965E-21	5.669E-21
9	2.00	3.339E-15	4.575E-21	5.210E-21
10	1.50	8.447E-15	1.250E-20	1.427E-20
11	1.00	3.286E-15	5.291E-21	6.047E-21
12	.70	8.134E-16	1.358E-21	1.578E-21
13	.30	3.766E-16	6.251E-22	7.117E-22
		---------	---------	---------
		4.366E-14	5.161E-20	6.132E-20

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	5.188E-15	4.410E-21	5.344E-21
2	7.25	4.960E-16	4.365E-22	5.208E-22
3	6.50	2.378E-15	2.188E-21	2.568E-21
4	5.50	2.792E-15	1.256E-21	3.238E-21
5	4.50	5.066E-15	5.320E-21	6.130E-21
6	3.50	4.088E-15	4.702E-21	5.356E-21
7	2.80	2.216E-15	2.726E-21	3.125E-21
8	2.50	3.542E-15	4.499E-21	5.137E-21
9	2.00	2.963E-15	4.059E-21	4.622E-21
10	1.50	7.252E-15	1.073E-20	1.226E-20
11	1.00	2.687E-15	4.327E-21	4.945E-21
12	.70	6.411E-16	1.071E-21	1.244E-21
13	.30	2.314E-16	3.841E-22	4.374E-22
		---------	---------	---------
		3.954E-14	4.611E-20	5.492E-20

TABLE 2-6 (Continued)

EXTRA CORE REGIONS - TOTAL

RECEIVER POINT A=0.998
COORDINATES R....... 4.08932E+01
Z....... 9.82485E+02
PHI..... 0.

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	1.474E-10	1.474E-10	1.474E-10	1.707E-14	2.626E-15
2	9.00	6.680E-10	6.680E-10	6.680E-10	7.355E-14	1.128E-14
3	8.00	1.512E-09	1.512E-09	1.512E-09	1.676E-13	2.588E-14
4	7.00	3.409E-09	3.409E-09	3.409E-09	3.641E-13	5.519E-14
5	6.00	7.647E-09	7.647E-09	7.647E-09	8.167E-13	1.238E-13
6	5.00	1.703E-08	1.703E-08	1.703E-08	1.807E-12	2.730E-13
7	4.00	3.759E-08	3.759E-08	3.759E-08	3.909E-12	5.597E-13
8	3.20	4.215E-08	4.215E-08	4.215E-08	4.124E-12	5.800E-13
9	2.50	9.651E-08	9.651E-08	9.651E-08	8.718E-12	1.138E-12
10	1.80	1.234E-07	1.234E-07	1.234E-07	1.187E-11	1.317E-12
11	1.30	1.200E-07	1.200E-07	1.200E-07	1.120E-11	1.131E-12
12	.95	9.326E-08	0.	9.326E-08	7.929E-12	7.199E-13
13	.70	7.447E-08	0.	7.447E-08	5.185E-12	4.914E-13
14	.50	6.202E-08	0.	6.202E-08	2.703E-12	3.565E-13
15	.40	4.301E-08	0.	4.301E-08	2.298E-12	2.194E-13
16	.30	4.434E-08	0.	4.434E-08	1.766E-12	1.741E-13
17	.20	4.532E-08	0.	4.532E-08	1.578E-12	1.684E-13
18	.10	2.525E-08	0.	2.525E-08	4.926E-13	5.745E-14
19	.09	5.083E-09	0.	0.	9.053E-14	1.084E-14
20	.08	5.557E-09	0.	0.	9.292E-14	1.073E-14
21	.07	6.448E-09	0.	0.	8.847E-14	1.136E-14
22	.06	7.881E-09	0.	0.	8.992E-14	1.225E-14
23	.05	1.007E-08	0.	0.	9.457E-14	1.353E-14
24	.04	1.335E-08	0.	0.	9.617E-14	1.517E-14
25	.03	1.822E-08	0.	0.	9.292E-14	1.630E-14
26	.02	2.541E-08	0.	0.	7.765E-14	1.625E-14
27	.01	1.798E-08	0.	0.	2.118E-14	6.187E-15
		---------	---------	---------	---------	---------
		9.478E-07	4.501E-07	8.378E-07	6.577E-11	7.517E-12

EXTRA CORE REGIONS - TOTAL

TABLE 2-6 (Continued)

```
RECEIVER POINT  A=0.998
COORDINATES R......     4.08932E+01
            Z......     9.82485E+02
            PHI....     0.

          RADS(E)/HR

1   1.00    4.246E-12
            ---------
            4.246E-12
```

CUMULATIVE SUMMARY RESULTS OVER ALL SUBSETS OF SOURCE REGIONS

NUCLEAR SUBSYSTEM - TOTAL

```
RECEIVER POINT  A=0.998
COORDINATES R......     4.08932E+01
            Z......     9.82485E+02
            PHI....     0.
```

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	5.084E-10	4.322E-16	5.237E-16
2	7.25	5.998E-11	5.279E-17	6.298E-17
3	6.50	3.510E-10	3.230E-16	3.791E-16
4	5.50	3.798E-10	1.709E-16	4.405E-16
5	4.50	9.668E-10	1.015E-15	1.170E-15
6	3.50	1.186E-09	1.364E-15	1.554E-15
7	2.80	5.109E-10	6.284E-16	7.204E-16
8	2.50	7.340E-10	9.322E-16	1.064E-15
9	2.00	5.429E-10	7.438E-16	8.470E-16
10	1.50	5.628E-10	8.329E-16	9.511E-16
11	1.00	2.561E-10	4.123E-16	4.712E-16

TABLE 2-6 (Continued)

12	.70	2.094E-10	3.497E-16	4.062E-16
13	.30	1.410E-11	2.341E-17	2.666E-17
		---------	---------	---------
		6.283E-09	7.281E-15	8.617E-15

NUCLEAR SUBSYSTEM - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

		MEV/CM2-SEC	RADS(C)/HR	REM/HR
1	8.50	2.709E-10	2.303E-16	2.790E-16
2	7.25	2.760E-11	2.429E-17	2.898E-17
3	6.50	1.490E-10	1.371E-16	1.609E-16
4	5.50	1.432E-10	6.446E-17	1.662E-16
5	4.50	3.130E-10	3.286E-16	3.787E-16
6	3.50	3.073E-10	3.533E-16	4.025E-16
7	2.80	1.075E-10	1.322E-16	1.515E-16
8	2.50	1.444E-10	1.834E-16	2.094E-16
9	2.00	8.111E-11	1.111E-16	1.265E-16
10	1.50	6.358E-11	9.410E-17	1.075E-16
11	1.00	1.469E-11	2.366E-17	2.704E-17
12	.70	6.928E-12	1.157E-17	1.344E-17
13	.30	6.243E-14	1.036E-19	1.180E-19
		---------	---------	---------
		1.629E-09	1.694E-15	2.052E-15

NUCLEAR SUBSYSTEM - TOTAL

RECEIVER POINT A=0.998
COORDINATES R...... 4.08932E+01
Z...... 9.82485E+02
PHI.... 0.

TABLE 2-6 (Continued)

		TOTAL	E.GT.1MEV	E.LT.1MEV	REM/HR	(RADS-T)/HR
1	10.00	2.791E-10	2.791E-10	2.791E-10	3.232E-14	4.971E-15
2	9.00	1.219E-09	1.219E-09	1.219E-09	1.342E-13	2.057E-14
3	8.00	2.720E-09	2.720E-09	2.720E-09	3.017E-13	4.657E-14
4	7.00	6.133E-09	6.133E-09	6.133E-09	6.550E-13	9.929E-14
5	6.00	1.388E-08	1.388E-08	1.388E-08	1.482E-12	2.247E-13
6	5.00	3.137E-08	3.137E-08	3.137E-08	3.328E-12	5.029E-13
7	4.00	7.059E-08	7.059E-08	7.059E-08	7.341E-12	1.051E-12
8	3.20	8.052E-08	8.052E-08	8.052E-08	7.878E-12	1.108E-12
9	2.50	1.871E-07	1.871E-07	1.871E-07	1.690E-11	2.206E-12
10	1.80	2.423E-07	2.423E-07	2.423E-07	2.330E-11	2.585E-12
11	1.30	2.371E-07	2.371E-07	2.371E-07	2.214E-11	2.235E-12
12	.95	1.970E-07	0.	1.970E-07	1.675E-11	1.520E-12
13	.70	1.579E-07	0.	1.579E-07	1.099E-11	1.042E-12
14	.50	1.337E-07	0.	1.337E-07	5.825E-12	7.683E-13
15	.40	9.386E-08	0.	9.386E-08	5.016E-12	4.788E-13
16	.30	9.830E-08	0.	9.830E-08	3.915E-12	3.860E-13
17	.20	1.024E-07	0.	1.024E-07	3.564E-12	3.805E-13
18	.10	5.831E-08	0.	5.831E-08	1.138E-12	1.327E-13
19	.09	1.194E-08	0.	0.	2.126E-13	2.547E-14
20	.08	1.309E-08	0.	0.	2.189E-13	2.529E-14
21	.07	1.508E-08	0.	0.	2.069E-13	2.655E-14
22	.06	1.824E-08	0.	0.	2.081E-13	2.835E-14
23	.05	2.318E-08	0.	0.	2.177E-13	3.115E-14
24	.04	3.091E-08	0.	0.	2.227E-13	3.514E-14
25	.03	4.333E-08	0.	0.	2.210E-13	3.877E-14
26	.02	6.446E-08	0.	0.	1.970E-13	4.123E-14
27	.01	5.256E-08	0.	0.	6.192E-14	1.809E-14
		---------	---------	---------	---------	---------
		1.987E-06	8.732E-07	1.715E-06	1.324E-10	1.506E-11

NUCLEAR SUBSYSTEM - TOTAL

RECEIVER POINT A=0.998
COORDINATES R....... 4.08932E+01
Z....... 9.82485E+02
PHI..... 0.

RADS(E)/HR

TABLE 2-6 (Continued)

```
 1  1.00   7.855E-12
           ---------
           7.855E-12
ERROR IN INPUT DATA CARD AS FOLLOWS
-0-0        -0
```

2.6 CODE LOGIC

The general code logic used in the KAP VI code is presented in this section. The calculational procedure used in KAP VI is described in the following chart illustrated in Figures 2-1 and 2-2. The flow chart is constructed in a simplified form to illustrate to the user when a certain operation or calculation is performed. The symbolism used in the flow chart is shown in Figure 2-1 and the actual KAP-VI logical flow chart is given in Figure 2-2. Each of the principal operations performed by KAP-VI are described in Section 2.5. The logic of the code as presented in Figure 2-2 has the principal FORTRAN DO loops indicated as indexing loops A-S for simplicity. The KAP VI code logic is altered from the KAP V logic only in the logic to calculate gamma ray absorption coefficients. All other differences between KAP VI and KAP V are involved with calculations and/or input or output changes.

A description of the subroutines in the KAP VI code is presented in Table 2-7. These descriptions indicate the principal calculations performed by the subroutine in the code logic and are related to the flow chart in Figure 2-1 and the description of the method of selection in Section 2.7.

TABLE 2-7

Description of KAP VI Code Subroutines

Subroutine Name	Principal Function
KAP	Reads problem input data, performs data card format checks, initializes data storage, computes zone-boundary surface ambiguity-indices, performs numerical integration over source points in a source zone for each detector point.
FINSET	Performs setup of control data words for printout of final results.
FINOUT	Prints out the final results under control of subroutine FINSET.
DEBN	Prints real (floating point) arrays for code checkout.
DEBI	Prints integer (fixed point) array for code checkout.
KERNEL	Calculates attenuation kernels for neutrons (Albert-Welton, moments method monovariant or bivariant, polynomial) or gamma rays (exponential) depth penetration data (grams/cm^2) in each element or material in the KAP VI problem. Depth penetration data are computed by subroutine LENGTH.
LENGTH	Calculates the depth penetration in each element or material for each line - of-sight from a source point to a detector point. Calculates the geometry related data.
SOURCE	Calculates the source point distribution and normalized source data for each source zone based on input source distribution data.

TABLE 2-7 (Continued)

Subroutine Name	Principal Function
SIR	Calculates interpolated values of source distribution data for input distributions.
PPLOT	Not presently used.
LIBRE	Calculates group-wise gamma ray absorption coefficients (i.e., total cross sections) for elements based on internally stored bivariant polynomial coefficient data or interpolation of tabular data. Data are in units of $cm^2/gram$.
LIBER	Calculates group-wise gamma ray coefficients (i.e. total cross sections) for elements based on Tape 11 photoelectric and pair production library data and Klein-Nishina equations.
BUILD	Calculates cubic polynomial coefficients for use in buildup factor calculations based on group energies and internally stored bivariant polynomial coefficients.
SI	Performs parabolic interpolation of tabular data.
INOUT	Prints organized output of the input data and performs input data checks.
SIGK	Calculates the total Compton scatter cross section at an energy based on the Klein-Nishina equation for inelastic scattering of a photon with a free electron.
AL	Performs a log-log interpolation of tabular data.
PØUT	Prints alphanumeric title information.
ERROR	Prints alphanumeric error statement.
EXIT	Subroutine to simulate system routine with a STOP.
SLITE SLITET	Subroutines to simulate system sense light operations for use in LENGTH subroutine.

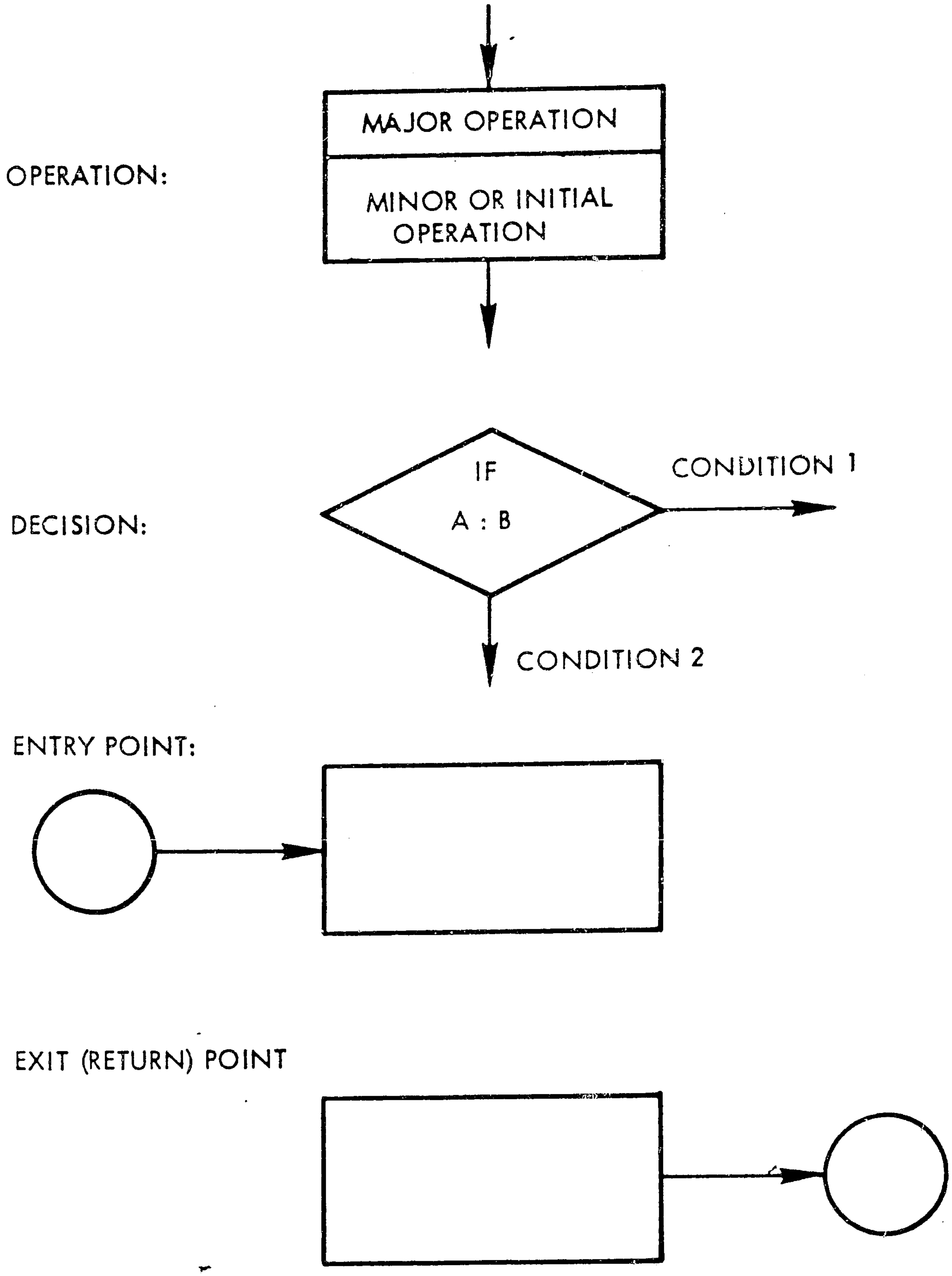
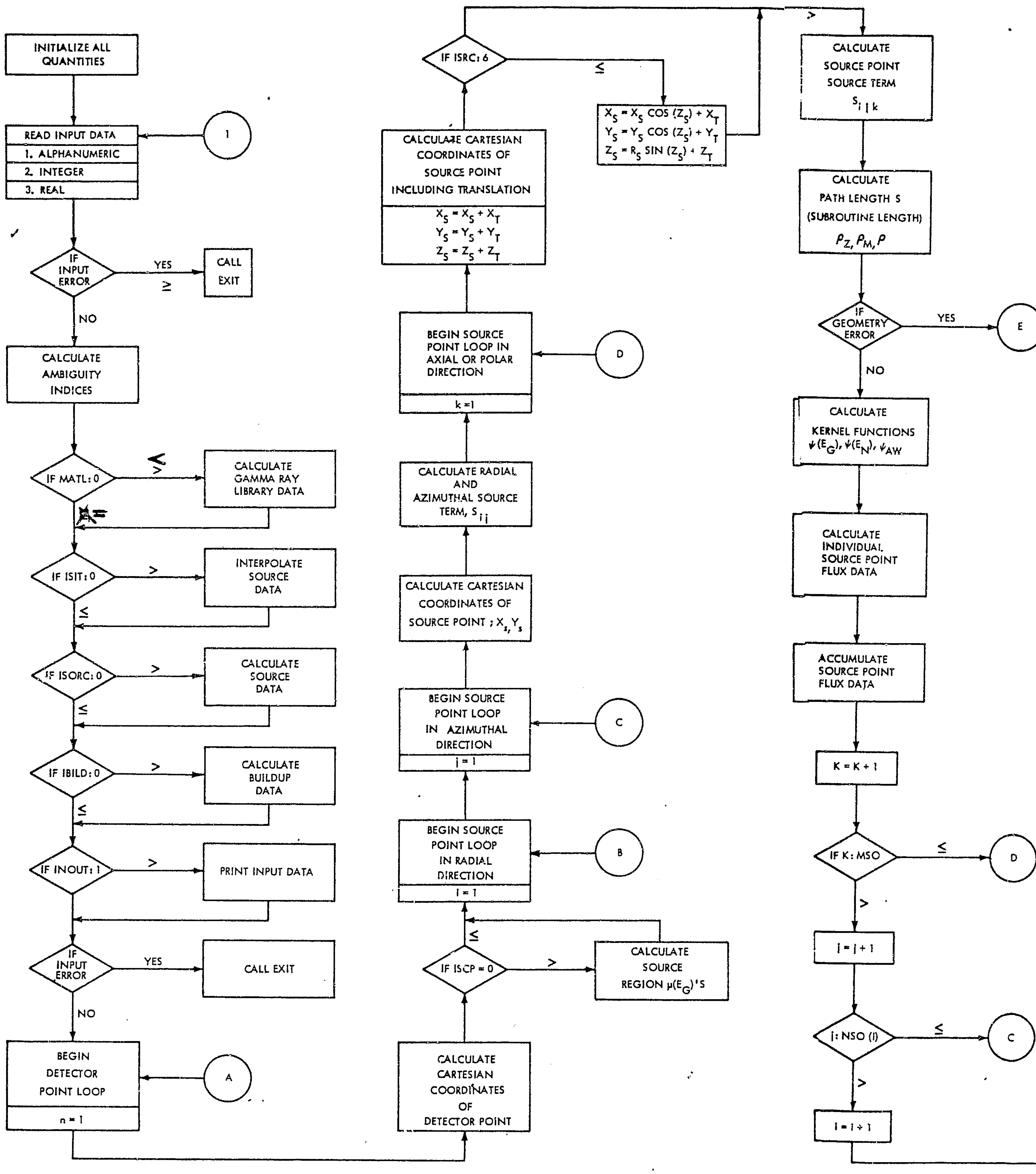


Figure 2-1. Flow Chart Symbolism



FOLDOUT FRAME 1

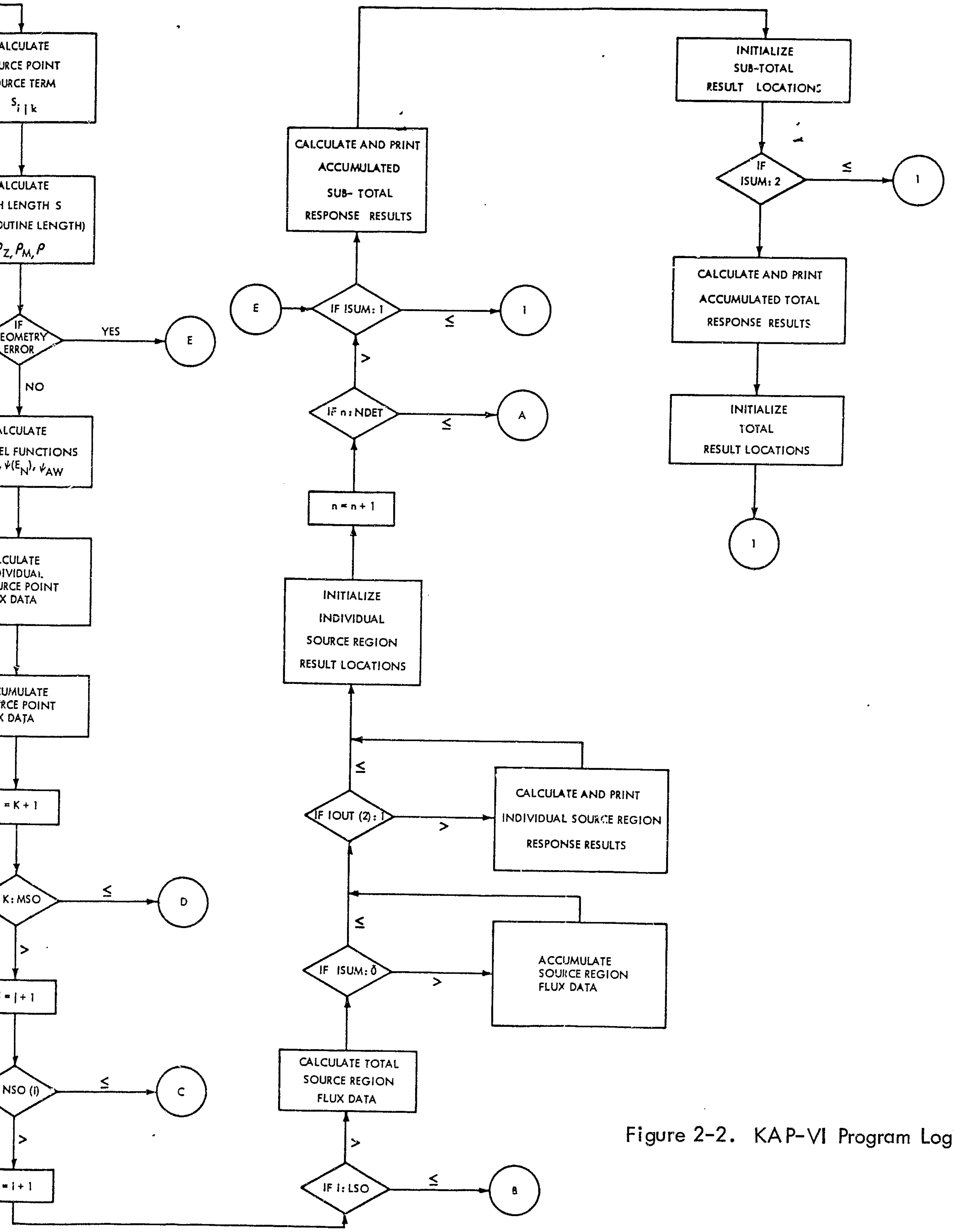


Figure 2-2. KAP-VI Program Logic

2.7 METHOD OF SOLUTION

The KAP VI (Point Kernel Attenuation Program) code employs the point kernel method to calculate neutron and gamma ray radiation levels at detector points located within or outside a complex geometry (including the radiation source) describable by a combination of quadratic surfaces. The attenuation function, or kernel, for gamma rays employs exponential attenuation along with a buildup factor to account for multiple scatter. Three optional fast neutron attenuation functions are included: (1) a modified Albert-Welton function for calculating fast neutron dose rate using removal cross sections; (2) a bivariant polynomial expression for computing neutron spectra using infinite media moment data; and (3) a monovariant polynomial expression for computing neutron spectra using infinite media moments data. The program also handles either cylindrical, spherical, disc, line, or point sources. A variety of options are available for describing neutron or gamma ray source distributions in complex geometries. A description of the geometry dependent calculations and energy dependent calculations and the relationship of input data to the method of solution in the KAP VI code are given in this section.

The KAP VI code requires the following input information in order to perform geometry and energy dependent calculations:

1) zone descriptions which are defined by intersecting surfaces,
2) geometric surfaces which are described by forms of the quadratic equations,
3) compositions in the zones which are described by a material-composition table, and
4) nuclear properties of the materials.

Based on this geometric data, the KAP VI program calculates the "line-of-sight" distance (path length) through each material in each zone between each source point and the detector point.

Subsequent sections describe the techniques used in describing and solving geometry dependent quantities for a KAP VI problem.

2.7.1 Geometric Surfaces

The geometry of a KAP VI problem can include the following types of equation surfaces:

1) Equations of a surface of revolution about any x, y, or z coordinate axis.
2) Equations of a plane normal to the x, y, or z axis of the reference system.
3) Equations of an elliptic cylinder about any z axis.
4) Equations of any quadratic surface by specifying appropriate equation coefficients.

To simplify the geometry description, the program contains specific forms of these quadratic surface equations. Each of these equations are identified by an equation number (value of input quantity NEQBD). The equations available are as follows:

$$A(x^2) + B(y^2) + C(z^2) + X_0x + Y_0y + Z_0z - D = 0 \qquad \text{(NEQBD = 1)}$$

$$A(x - X_0)^2 + B(y - Y_0)^2 + C(z - Z_0)^2 - D^2 = 0 \qquad \text{(NEQBD = 2)}$$

$$(x - X_0)^2 + (y - Y_0)^2 - D^2 = 0 \qquad \text{(NEQBD = 3)}$$

$$x - D = 0 \qquad \text{(NEQBD = 4)}$$

$$y - D = 0 \qquad \text{(NEQBD = 5)}$$

$$z - D = 0 \qquad \text{(NEQBD = 6)}$$

The equation coefficients A, B, C, X_0, Y_0, Z_0, and D are input data for the surfaces in a problem. The surface equation number defines the necessary coefficients, and only those coefficients necessary to solve the respective surface equation is required input.

The surface defined by NEQBD = 4, 5, or 6 is a plane normal to one of the coordinate axes. NEQBD = 3 is the equation for a cylindric surface with its axis parallel to the z axis. NEQBD = 2 is an elliptic surface which, by specifying the A, B, and C coefficients properly, can describe elliptical cylindric surfaces with their axis parallel to each of the coordinate axes. NEQBD = 1 is a form of the general quadratic equation. By proper manipulation of the coefficient of a quadratic equation defining a surface, one can calculate the required coefficients A, B, C, D, X_0, Y_0, and Z_0.

The equations shown above require that all coefficients must be in units consistent with the nuclear properties of the zones.

The maximum number of geometric surfaces that can be employed in a KAP VI problem is limited to 100 surfaces with a maximum of 6 surfaces per zone.

2.7.2 Geometric Zones

A zone is defined as a region containing a homogeneous composition of materials and bounded by a set of intersecting geometric surfaces as defined by the surface equations. Geometric surfaces described in a problem geometry are used to define the exterior 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 the sequence number (1 to 100) of the geometric surfaces.

KAP VI uses the "point-in-zone" technique to assign the boundary surface-zone relationship values to each of the zone boundary numbers. This relationship of the zone with respect to each of its boundary surfaces must be known for a KAP VI 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 KAP VI code requires as input the Cartesian coordinates of a point (x_p, y_p, z_p) within each zone. Using these point coordinates (input values of XYZ), the designated surface number (input values of LBD) for each boundary of a zone, and the equation number (input value of NEQBD) of the designated surface, the calculation of the ambiguity index is straightforward. The surface equation and the coordinates (X_p, Y_p, Z_p) define the quantity, V, for each particular equation number (NEQBD = 1 through 6) as follows:

$$V = A(x_p - X_0)^2 + B(y_p - Y_0)^2 + C(z_p - Z_0)^2 + X_0x_p + Y_0y_p + Z_0z_p - D \quad (NEQBD = 1)$$

$$V = A(x_p - X_0)^2 + B(y_p - Y_0)^2 + C(z_p - Z_0)^2 - D \quad (NEQBD = 2)$$

$$V = (x_p - X_0)^2 - (y_p - Y_0)^2 - D \quad (NEQBD = 3)$$

$$V = x_p - D \quad (NEQBD = 4)$$

$$V = y_p - D \quad (NEQBD = 5)$$

$$V = z_p - D \quad (NEQBD = 6)$$

The sign ($\pm$) of the quantity V determines the ambiguity index of the boundary surface of the zone. This ambiguity index for each surface is assigned to the input boundary surface number, LBD. If V is negative, the zone is internal to the boundary surface and the boundary surface number, LBD, is given a positive sign. Similarly, if V is positive, the zone is external to the boundary surface and the boundary surface number, LBD, is given a negative sign. The ambiguity index calculation is performed at the beginning of each KAP VI source region calculation, and the computed signs are used for all geometry calculations for this source region.

External zones 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 quantityof the number of boundaries for a zone (input value at NBNDZN) is a negative number.

2.7.3 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_D, y_D, z_D). These coordinates are computed as follows:

$$x_S = \overline{R}_i \cos \overline{\theta}_{k,i}$$

$$y_S = \overline{R}_i \sin \overline{\theta}_{k,i} \qquad \underline{\text{Cylindrical}} \text{ Source Point}$$

$$z_S = \overline{Z}_i$$

or:

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:

$$\rho = \sqrt{(x_D - x_S)^2 + (y_D - y_S)^2 + (z_D - z_S)^2}$$

$$\alpha = \frac{x_D - x_S}{\rho}$$

$$\beta = \frac{y_D - y_S}{\rho}$$

$$\gamma = \frac{z_D - z_S}{\rho}$$

The next step in the geometry calculation is to obtain the path length, ρ_Z, traversed in each region 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 related to the original source point by the input value, FUDGE, designated by 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 coefficients, and the source zone number to calculate the <u>correct</u> 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 specified by the input value, IZSO. The values of V_{bZ} depend on the equation number $NEQBD_b$ of boundary, b, and follow as:

$$V_{bZ} = A(x' - X_0)^2 + B(y' - Y_0)^2 + C(z' - Z_0)^2 + X_{0x}' + Y_{0y}' + Z_{0z}' - D^2$$

$$V_{bZ} = A(x' - X_0)^2 + B(y' - Y_0)^2 + C(z' - Z_0)^2 - D^2$$

$$V_{bZ} = (x' - X_0)^2 - (y' - Y_0) - D$$

$$V_{bZ} = x' - D$$

$$V_{bZ} = y' - D$$

$$V_{bZ} = z' - D$$

4

$$x_S = \bar{R}_i \cos \bar{\theta}_{k,i} \sin \bar{\phi}_i$$
$$y_S = \bar{R}_i \sin \bar{\theta}_{k,i} \sin \bar{\phi}_i$$
$$z_S = \bar{R}_i \cos \bar{\phi}_i$$

Spherical Source Point

$$x_D = R_D \cos \theta_D$$
$$y_D = R_D \sin \theta_D$$
$$z_D = Z_D$$

Detector Point

where:

$\bar{R}_i$ = arithmetic mean based on areas of the source interval bounded by the radii R_i and R_{i+1}.

$$\bar{R}_i = \sqrt{\frac{R_{i+1}^2 + R_i^2}{2}}$$

$\bar{\theta}_{k,i}$ = the arithmetic mean of the azimuthal source interval for each radial interval, i, bounded by $\theta_{k,i}$ and $\theta_{k+1,i}$, i.e.,

$$\bar{\theta}_{k,i} = \frac{\theta_{k+1,i} + \theta_{k,i}}{2}$$

$\bar{Z}_i$ = the arithmetic mean of the axial source interval bounded by Z_i and Z_{i+1}, i.e.,

$$\bar{Z}_i = \frac{Z_{i+1} + Z_i}{2}$$

$\bar{\phi}_i$ = the arithmetic mean of the polar source interval bounded by $_i$ and $_{i+1}$, i.e.,

$$\bar{\phi}_i = \frac{\phi_{i+1} + \phi_i}{2}$$

R_D = the radial coordinate of the detector point (input to the problem)

θ_D = the azimuthal coordinate of the detector point (input to the problem)

Z_D = the axial coordinate of the detector point (input to the problem)

If the sign of the quantity, V_{bZ}, and the sign (ambiguity index) of the boundary surface number LBD_{bZ} are of opposite sign for all boundary surfaces, the point (x', y', z') lies within the zone, Z. If the point does not lie in the IZSO zone, the program searches the zones in a specific order as follows: IZSO + 1, IZSO +2, ... up to the number of zones, NREG; then it begins with Zone 1, 2, etc. up to IZSO-1. 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 from the "pseudo-point" (x', y', z') to the correct boundary. This quantity is defined as ρ'_Z.

At this point in the calculation, the correct path length in the zone is calculated as:

$$\rho_Z = \rho'_Z + \Delta$$

The material path lengths, ρ_m, for each material, m, are immediately calculated as cumulative sums from ρ_Z, and composition material matrix values, $\theta_{m,c}$ in Table 2-8 and as follows:

$$\rho_m = \rho_m + \rho_Z \cdot \theta_{m,c}$$

In the above equation, c is the specific composition of the zone, Z, (quantities, $\theta_{m,c}$, are discussed in the next section), and ρ_m is set to zero at the beginning of each source-to-detector calculation. 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. The input values, $NTRYZN_{bZ}$, determine 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:

$$x' = x' + \alpha\rho_Z$$

$$y' = y' + \beta\rho_Z$$

$$z' = z' + \gamma\rho_Z$$

TABLE 2-8

ELEMENT OR MATERIAL COMPOSITION MATRIX ($\theta_{M,C}$)

Element or Material Number, M

Composition Number, C	1	2	3	4.	MAT
1	$\theta_{1,1}$	$\theta_{2,1}$	$\theta_{3,1}$	$\theta_{4,1}$	$\theta_{MAT,1}$
2	$\theta_{1,2}$	$\theta_{2,2}$	$\theta_{3,2}$	$\theta_{4,2}$	$\theta_{MAT,2}$
3	$\theta_{1,3}$	$\theta_{2,3}$	$\theta_{3,3}$	$\theta_{4,3}$	$\theta_{MAT,3}$
.	.	.	.	. . . .	.
.	.	.	.	. . . .	.
.	.	.	.	. . . .	.
.	.	.	.	. . . .	.
.	.	.	.	. . . .	.
.	.	.	.	. . . .	.
.	.	.	.	. . . .	.
NCOMP	θ_{1}, NCOMP	θ_{2}, NACOMP	θ_{3}, NCOMP	θ_{4}, NCOMP	$\theta_{MAT,NCOMP}$

$$\rho_m = \sum_Z \theta_{m,c} \cdot \rho_Z$$

where the composition number, c, is specified as being in zone, Z.

Values of ρ are used in calculating the neutron and/or groupwise gamma ray depth penetration for each source point-to-detector point path length through each element or material, m.

A "void" is defined as a composition with zero density or volume fraction for each constituent in the matrix.

Nuclear data, such as gamma ray absorption coefficients or neutron removal cross sections in a KAP VI problem are required for each constituent (element or material) in the material matrix. Specifically, required nuclear properties are the groupwise gamma ray mass or linear absorption coefficients, $(\mu/\rho)_m$, or μ_m, and the mass or linear neutron removal cross sections, $(\Sigma/\rho)_m$ of Σ_m. The user must input (or compile from the library as discussed in Section 2.7.7) these quantities in dimensions consistent with the material matrix quantities, $\theta_{m,c}$. For example, if $(\mu/\rho)_m$ and $(\Sigma/\rho)_m$ are input in units of cm^2/gram, then $\theta_{m,c}$'s must be in units of grams/cm^3.

2.7.4 Zone Source Description

The KAP VI code accepts either a cylindrical or a spherical source region, as well as the basic source geometries of a point, line, or disk. Source distributions in cylindrical or spherical geometry is assumed separable in the spatial (radial, axial, or polar, and azimuthal) coordinates. Source energy distribution is input as a separate quantity.

Source distributions can be input as unnormalized radial and/or axial source data. The code integrates and normalizes the input distribution data to obtain the source strength of the source point representing each finite source volume in the source region.

The code assumes that the azimuthal distribution of the source density is uniform. The uniform azimuthal distribution data is used within the code to properly normalize the source.

The same distribution may be assumed for the gamma ray and neutron source, or, the user may specify a different source distribution and normalization constant for gamma rays and neutrons.

Source Energy Distribution

The quantity, $\Gamma(E_n$ or $E_G)$, defines the source strength in each energy group. The gamma ray source strength, $\Gamma(E_G)$, may represent the number of particles (or photons) of energy, E_G, or energy release (MeV) at energy E_G. The user must provide data which is dimensionally consistent data with the total power (or gamma source strength) input value, $A_{T,1}$, for the source zone.

The neutron energy distribution parameters, $\Gamma(E_n)$, for the neutron differential energy spectrum function can be input as integration factors, ΔE_n, or as parameters to convert the neutron spectra data from units of one fission source neutron to units of neutrons per fission or per watt. Also the quantity, $\Gamma(E_n)$, allows the user to input the total power or total fission rate in order to make the spectral data dimensionally consistent. The units of $\Gamma(E_n)$ must be dimensionally consistent with the total power (or neutron source strength) input value, $A_{T,2}$, for the source zone.

Although the Albert-Welton function computes an energy independent dose rate based on a fission spectrum source, a separate quantity, Γ_{AW}, may be input to the code to provide a "source strength" for use with this function.

Source Spatial Distribution

The spatial dependence of the source in a KAP VI source zone is represented as a finite number of volume elements, each of which are represented as a source point. The source density at each source point, and the location of each source point, are determined by the code from input source parameters. The program includes techniques to calculate source point densities from: (1) analytical functions (uniform or flat, cosine, exponential), or (2) pointwise source values. The unnormalized source densities for gamma rays or neutrons are defined as the separable quantities: $f(\overline{R}_i)$, $f(\overline{Z}_j)$, $f(\overline{\phi}_j)$, and $f(\overline{\theta}_{k,i})$, for the space coordinates of R (radius for cylindrical or spherical sources), Z (axial dimension for cylindrical sources), ϕ (polar angle for spherical sources), and θ (azimuthal angle for cylindrical and spherical sources), respectively.

By means of the input quantities, (ISRC, ISZC, and ISTC), the code user selects a technique for calculating the source density variation of interest.

Source Point Coordinates

The location of each source point in a KAP VI source zone is defined by coordinates calculated from the input source parameters. In the cylindrical or spherical source zones, the source point is placed at the radius, $\overline{R}_i$, of each annular source interval bounded by the input valued R_i and R_{i+1}. The radius, $\overline{R}_i$, is defined as follows:

$$\overline{R}_i = \sqrt{\frac{R_{i+1}^2 + R_i^2}{2}}$$

In a similar fashion, the axial or polar coordinate of the source point is defined as the arithmetic mean, $\overline{Z}_i$, or $\overline{\phi}_i$, of each axial or polar source interval bounded by the input values, Z_i and Z_{i+1}, or ϕ_i and ϕ_{i+1}. The axial or polar coordinate is defined as follows:

$$\overline{Z}_i = \frac{Z_{i+1} + Z_i}{2}$$

$$\overline{\phi}_i = \frac{\phi_{i+1} \quad \phi_i}{2}$$

The azimuthal coordinate, $\overline{\theta}_k$, is defined from the input data as the arithmetic mean of the input data as the arithmetic mean of the input values, θ_k, θ_{k+1}, or equal spaced internally calculated values of θ_k as follows:

$$\overline{\theta}_k = \frac{\theta_{k+1} + \theta_k}{2}$$

Source Density Description

The cylindrical and spherical source density functions available in the KAP VI code are derived from analytic functions or input pointwise data. The radial and axial or polar source density functions, $f(\overline{R}_i)$, $f(\overline{Z}_i)$, $f(\overline{\phi}_i)$ defines the unnormalized source densities at the radial coordinate at $\overline{R}_i$, $\overline{Z}_i$, or $\overline{\phi}_i$.

These data are used with the azumuthal source density functions to obtain the point source value. Azimuthal source densities are normalized data and are described in later sections. The radial and axial or polar source density functions are defined in following paragraphs.

Source Density from Analytical Functions

The source densities obtained from analytical functions available in the KAP VI code and input data to a KAP VI problem are as follows:

Cylinder - Uniform Source Density (ISRC = 1)

$$f(\overline{R}_i) = \int_{R_i}^{R_{i+1}} R dR$$

where values of R_i are required input.

Cylinder - Cosine Variation of Source Density (ISRC = 2)

$$f(\overline{R}_i) = \int_{R_i}^{R_{i+1}} \cos \chi_1 \left[R - \chi_2\right] R dR$$

where values of χ_1, χ_2 and R_i are required input.

Cylinder - Exponential Variation of Source Density (ISRC = 4)

$$f(\overline{R}_i) = \int_{R_i}^{R_{i+1}} \chi_2 \cdot \exp \left[\chi_1 R\right] R dR$$

where values of χ_1, χ_2 and R_i are required input.

Sphere - Uniform Source Density (ISRC = 6)

$$f(\overline{R}_i) = \int_{R_i}^{R_{i+1}} R^2 dR$$

where values of R_i are required input.

Cylinder - Uniform Source Density (ISZC = 1)

$$f(\overline{Z}_i) = \int_{Z_i}^{Z_{i+1}} dZ$$

where values of Z_i are required input.

Cylinder - Cosine Variation of Source Density (ISZC = 2)

$$f(\overline{Z}_i) = \int_{Z_i}^{Z_{i+1}} \cos \xi_1 \left[Z - \xi_2\right] dZ$$

where values of ξ_1, ξ_2 and Z_i are required input.

Cylinder - Exponential Variation of Source Density (ISZC = 4)

$$f(\overline{Z}_i) = \int_{Z_i}^{Z_{i+1}} \xi_2 \cdot \exp \left[\xi_1 Z\right] dZ$$

where values of ξ_1, ξ_2 and Z_i are required input.

Spherical - Uniform Variation of Source Density (ISZC = 6)

$$f(\overline{\Phi}_i) = \int_{\phi_i}^{\phi_{i+1}} \cos \phi \, d\phi$$

where values of ϕ_i are required input.

Source Density from Pointwise Input Data

Pointwise source density can be calculated from input point values at source interval coordinates (R_i, R_{i+1} or Z_i, Z_{i+1}) of each interval in the source zone, or as point values calculated from input point values at spatial coordinates other than the desired source point coordinates.

Input point values defined as $g(R_i)$ at R_i and $g(Z_i)$ or $g(\phi_i)$ at Z_i or ϕ_i are used directly in the program to obtain the source density parameters of $f(\overline{R}_i)$, $f(\overline{Z}_i)$, $f(\overline{\Phi}_i)$. The use of these point values are specified by the input values ISRC and ISZC. The techniques used for direct input value calculations are based on a source variation between two adjacent spatial coordinates, i.e., R_i, R_{i+1}, Z_i, Z_{i+1}, or Φ_i, Φ_{i+1}. The point value calculation for cylindrical and spherical source zones follow as:

Cylinder - Linear Variation of Source Density (ISRC = 3)

$$f(\bar{R}_i) = \int_{R_i}^{R_{i+1}} \left[aR + b\right] RdR$$

where a and b are computed internally by the code from the adjacent values $g(R_i)$ at R_i and $g(R_{i+1})$ at R_{i+1}.

Cylinder - Exponential Variation of Source Density (ISRC = 5)

$$f(\bar{R}_i) = \int_{R_i}^{R_{i+1}} \chi_2 \cdot \exp \left[\chi_1 R\right] RdR$$

where χ_1 and χ_2 are computed internally by the code from the adjacent values $g(R_i)$ at R_i and $g(R_{i+1})$ at R_{i+1}.

Sphere - Linear Variation of Source Density (ISRC = 7)

$$f(\bar{R}_i) = \int_{R_i}^{R_{i+1}} \left[aR + b\right] R\,dR$$

where a and b are computed internally by the code from the adjacent values $g(R_i)$ at R_i and $g(R_{i+1})$ at R_{i+1}.

Cylinder - Linear Variation of Source Density (ISZC = 3)

$$f(\bar{Z}_i) = \int_{Z_i}^{Z_{i+1}} \left[aZ + b\right] dZ$$

where a and b are computed internally by the code from the adjacent values $g(Z_i)$ at Z_i and $g(Z_{i+1})$ at Z_{i+1}.

Cylinder - Exponential Variation of Source Density (ISZC = 5)

$$f(\overline{Z}_i) = \int_{Z_i}^{Z_{i+1}} \xi_2 \cdot \exp \left[\xi_1 Z \right] dZ$$

where ξ_1 and ξ_2 are computed internally by the code from the adjacent values $g(Z_i)$ at Z_i and $g(Z_{i+1})$ at Z_{i+1}.

The technique of calculating point values from input point values at spatial coordinates other than the desired spatial coordinates is a very useful facet of the KAP VI code. The input point values may be representative of a fine radial mesh output from a DOT-IIW discrete ordinates transport code problem. The fine mesh may, however, provide too many source points for economical use in a point kernel calculation. Therfore, the user of the KAP VI code can input the exact transport code output data, of g'(R) versus R', and the code will interpolate new point values g(R) at R, where the values of the new radial mesh, R, are selected to better represent a point kernel source point description. The point values g(R) at R are used in the equations described above to calculate the pointwise source density. This interpolation technique is controlled by the input quantity ISIT, and the spatial distributions of the source are input as the point values, FSIT, at RSIT and ZSIT, as described in Section 2.2.

Azimuthal Source Density

The azimuthal source density function is assumed to be uniform in the azimuthal space variable, θ, for cylindrical and spherical source regions. The user of the KAP-VI code has the option of specifying the mode in which the routine will subdivide the θ variable into intervals as follows:

Same Number of Azimuthal Intervals in All Radial Intervals (ISTC = 1)

$$f(\overline{\theta}_{k,i}) = \int_{\theta_{k,i}}^{\theta_{k+1,i}} d\theta$$

Required input, $\theta_{k,1}$

Variable Number of Azimuthal Intervals in Each Radial Interval (ISTC = 2)

$$f(\overline{\theta}_{k,i}) = \int_{\theta_{k,i}}^{\theta_{k+1,i}} d\theta$$

$\theta_{k,i}$ are required input for each radial interval

Variable Number of Azimuthal Intervals in Each Radial Interval (ISTC = 3)

$$f(\overline{\theta}_{k,i}) = \frac{\int_{\theta_{k,1}}^{\theta_{k+1,i}}}{k_i} d\theta$$

k_i is required input for radial intervals

These three options allow description of the three possible variations shown in Figure 2.3. One additional option is available to the code user: if discrete point sources are of interest, then the quantity ISRC is input as a zero, and the source density is input as $f(\bar{R})$, $f(\bar{Z})$, and $f(\bar{\theta})$. This option allows the user to describe a non-uniform source density in the azimuthal variable, θ.

Normalization of Zone Source

The source normalization routine in the KAP-VI code gives the user the versatility to input the source distribution data in an unnormalized form. The code normalizes the zone source by using the azimuthal source density by the following equations:

Cylindrical Source Region

Gamma Ray Source

$$P'_1 = \frac{A_{T,1}}{\left[\theta_{1,k+1} - \theta_{1,1}\right] \cdot \int_R \int_Z f_1(\bar{R}_i) \cdot f_1(\bar{Z}_j) \cdot R\, dR\, dZ}$$

$$f'_1(\bar{\theta}_{k,i}) = P'_1 \cdot f_1(\bar{\theta}_{k,i})$$

where:

$A_{T,1}$ = the gamma ray source normalization constant which is input as ASOI (1)

$\theta_{1,k+1}$ = the upper limit of the θ variable for the gamma ray problem

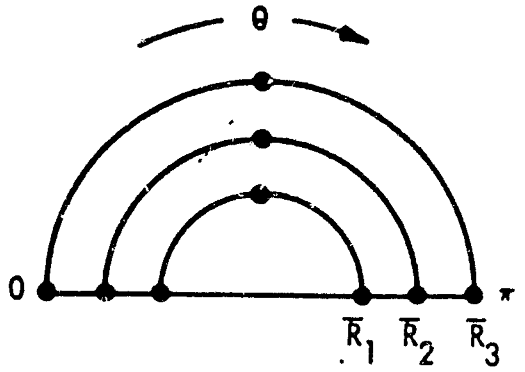
$\theta_{1,1}$ = the lower limit of the θ variable for the gamma ray problem

$f_1(\bar{R}_i)$ = the unnormalized gamma ray source density at each radius, R_i

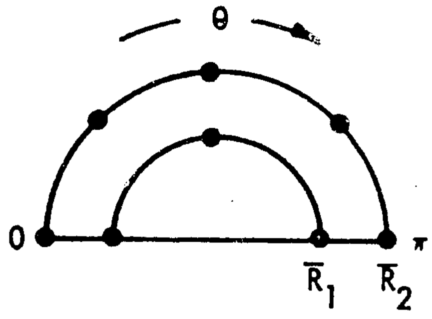
$f_1(\bar{Z}_j)$ = the unnormalized gamma ray source density at each value of Z_j

$f_1(\bar{\theta}_{k,i})$ = the unnormalized gamma ray source density at each azimuthal value θ_k for each radial position, i, (i.e., $\Delta\theta_{k,i}$).

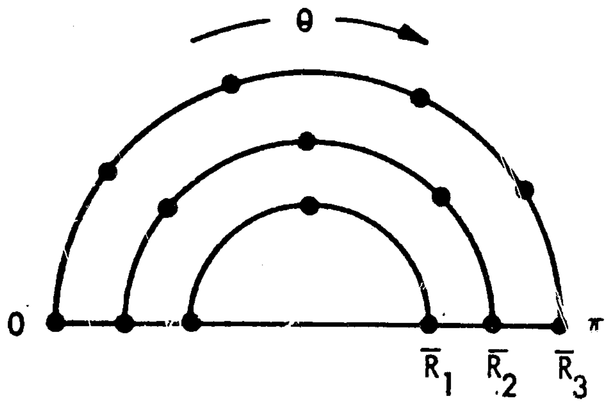
SOURCE GEOMETRY	INPUT DATA



IF ISTC = 1, $\theta_{K,1}$ IS INPUT AS 0.0, 1.5708, 3.1416



IF ISTC = 2, $\theta_{K,1}$ IS INPUT AS 0, 1.5708, 3.1416, $\theta_{K,2}$ IS INPUT AS 0, .7854, 1.5708, 2.3562, 3.1416



IF ISTC = 3,
K_1 IS INPUT AS 2,
K_2 IS INPUT AS 4,
K_3 IS INPUT AS 5,
$\theta_{K,1}$ IS INPUT AS 0.0, and
$\theta_{K,2}$ IS INPUT AS 3.14159

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Figure 2-3. Examples of Azimuthal Source Density Description

Neutron Source

If the neutron source strength, ASO! (2), is input as zero, then the program uses the gamma ray source, $A_{T,1}$, and distributions for neutrons and solves the same equation described for gamma rays. If ASOI(2) is not input as zero, then the program solves the following equations:

$$P'_2 = \frac{A_{T,2}}{\left[\theta_{1,k+1} - \theta_{1,1}\right] \cdot \int_R \int_Z f_2(\bar{R}_i) \cdot f_2(\bar{Z}_i)\, R\, dR\, dZ}$$

$$f'_2(\bar{\theta}_{k,i}) = P'_2 \cdot f_2(\bar{\theta}_{k,i})$$

where all terms were previously defined and the subscript 2 refers to neutron data.

The normalized quantity, $f'(\bar{\theta}_{k,i})$, and the unnormalized quantities, $f(\bar{R}_i)$ and $f(\bar{Z}_i)$, provide the source magnitude of the source point defined at the coordinates $\bar{R}_i$, $\bar{Z}_i$, and $\bar{\theta}_{k,i}$ as $S(\bar{R}_i, \bar{Z}_i, \bar{\theta}_{k,i})$ in units of watts, particles per second and these data must be dimensionally consistent with the input gamma ray and neutron or Mev energy distribution data.

These source data are stored internally to the code and are used in the definition of the source magnitude for each source-to detector calculation.

The user has the option of specifying the source region azimuthal parameters, $\theta_{1,k+1}$, $\theta_{1,1}$, or $\theta_{2,k+1}$, $\theta_{2,1}$ such that the source region symmetry is accounted for in the normalization. If $A_{T,1}$ or $A_{T,2}$ is total power (or source strength), and if $\theta_{1,k+1}$ and $\theta_{1,1}$ are π and 0. 0, the power or source density is effectively twice that in the source zone. Hence, each source point source at $\theta_{1,k}$ includes its mirror image at $\theta_{1,} + \pi$

Spherical Source Region

Gamma Ray Source

$$P'_1 = \frac{A_{T,1}}{\left[\theta_{1,k+1} - \theta_{1,1}\right] \cdot \int_\phi \int_R \sin(\phi) \cdot f_1(\bar{\phi}_i) \cdot f_1(\bar{R}_i) R^2 \, dR d\phi}$$

$$f_1'(\bar{\theta}_{k,i}) = P'_1 \cdot f_1(\bar{\theta}_{k,i})$$

where:

$f_1(\bar{\phi}_i)$ = the unnormalized gamma ray source density at each polar coordinate, $\bar{\phi}_i$ and all other terms are as previously defined.

Neutron Source

$$P_2' = \frac{A_{T,2}}{\left[\theta_{1,k+1} - \theta_{1,1}\right] \cdot \int_\phi \int_R \sin(\phi) \cdot f_2(\bar{\phi}_i) \cdot f_2(\bar{R}_i) R^2 \, dR d\phi}$$

$$f'_2(\bar{\theta}_{k,i}) = P'_2 \cdot f_2(\bar{\theta}_{k,i})$$

where all terms are as previously defined, and the subscript 2 refers to neutron data.

2.7.5 Material Attenuation Function Description

Fast Neutron

The KAP VI code contains three optional material attenuation functions for obtaining the attenuated neutron response at a detector point. The user can specify the use of the modified Albert-Welton material attenuation function[2], and either a bivariant or monovariant polynomial material attentuation function for calculating differential neutron spectra employing infinite media moments data. Various conversion factors can be applied to any of these three functions, as described in Section 2.7.6 for conversion of neutron flux or level to detector response in different units.

Fast Neutron Dose Rate

A modification of the Albert-Welton function is used to calculate the fast neutron dose rate from fission sources in mixtures of hydrogenous and heavy materials. This function combines a theoretical hydrogen cross section with integration over the fission neutron spectrum to obtain the uncollided flux or dose. Attenuation effects of non-hydrogenous materials are included by using exponential attenutation with effective neutron removal cross sections.

The basic assumption in the Albert-Welton function is that all heavy materials are followed by sufficient hydrogenous materials to validate the use of neutron removal cross sections for the heavy materials. In addition, the Albert-Welton function is an integral quantity calculated from theoretical consideration of the energy dependence of neutron cross sections and the variation of neutron spectrum with depth penetration in hydrogen. Hence, the Albert-Welton function dose rate does not include buildup of neutrons at lower energies.

The equation coded in the KAP VI code for computing the energy independent fast neutron response at the detector from each source point is:

$$D_n = \frac{\Gamma_{AW} \cdot S(\bar{R}_i, \bar{Z}_j, \bar{\theta}_k) \cdot \psi(W'_R, X_R)}{4\pi \rho^2}$$

where:

Γ_{AW} = the "source strength" for use in the Albert-Welton function

$S(\bar{R}_i, \bar{Z}_j, \bar{\theta}_k)$ = the volume weighted source strength for the source point, located at $\bar{R}_i, \bar{Z}_j, \bar{\theta}_k$, i

ρ = the distance (cm) from the source point to the detector point.

$$\psi(W'_R, X_R) = \alpha_1 \cdot \left[X_R\right]^{\alpha_2} \cdot \exp\left[-\alpha_3 \left(X_R\right)^{\alpha_4}\right] \cdot \exp\left[-W'_R\right]$$

$$W'_R = \sum_{m=1}^{M} \Sigma'_m \rho_m$$

$$X_R = \sum_{m=1}^{M} \eta_m \rho_m$$

Σ'_m = non-hydrogenous removal cross section for all materials, m

ρ_m = the path length for each material, m

η_m = the ratio of the hydrogen density in material m to the hydrogen density in water

α_1, α_2, α_3, and α_4 are constants.

The user will note that the units of X_R may be either cm or gm/cm^2 depending on the units of the path length (ρ_m). Hence, care must be exercised in applying the input quantity, η_m, to assure proper units.

Since the Albert-Welton function cannot be used to calculate the neutron dose rate for small values of X_R, the following equation (originally coded in Program 14-0)[(2)] is employed in the KAP VI code:

$$\Psi (W'_R, X_R) = \alpha_5 \cdot \exp \left[-\alpha_7 X_R\right] \cdot \exp \left[-W'_R\right], \quad \text{if } X_R < \alpha_6$$

Values of α_5, α_6, and α_7, are input to the code. The units of α_1, and α_5 must be compatible to provide proper units for dose rate calculations.

Neutron Spectra

Either a monovariant or a bivariant polynomial expression can be employed to calculate the differential neutron spectrum. The monovariant polynomial data are available as sets of data representing specific differential spectrum energy points and are solved only in the variable of material depth penetration, W_R. In contrast, the bivariant polynomial data are available as sets of data which are solved as a function of initial neutron energy, E_n, as specified by the user, and mateial depth penetration, W_R.

The monovariant and bivariant ploynomial representation of the moments method data is derived from the infinite medium moments method data such as that generated by the Nuclear Development Corporation (3). The polynomial coefficients are applicable over specific depth penetration or energy. The user of the KAP program specifies the applicable ranges of polynomial data. Both polynomials are based on the infinite medium of the particular material (hereafter called the reference material) used in the moments method calculation. The inclusion of other materials is based on their equivalent neutron removal in comparison to the reference material; hence, extreme care must be used in selecting the removal cross section for material in non-hydrogenous media (e. g., carbon and beryllium media). The equivalent depth penetration in the reference material is calculated in the program as:

$$W_R = \sum_{m=1}^{M} \Sigma_m \rho_m / \Sigma_r$$

where, Σ_R is the neutron removal cross section for this refernce material.

The user specifies a separate set of neutron removal cross sections, Σ_m, for the neutron spectra option which is not the same set that was used in the Albert-Welton function. The code then uses these cross section data in the evaluation W_R. A restriction of the moments data evaluation in the KAP VI code arises when the depth penetration exceeds the range of applicability of the polynomial data. The program automatically truncates the polynomial evaluation at $W_R = 120$ gm/cm^2. However, the user is provided with the capability to input energy dependent extrapolation parameters, $\lambda(E_n)$, for extending the range of the moments data functions.

The equation solved in the code for computing the differential neutron energy response at the detector from each source point for each scattered neutron energy, E_n is:

$$D_n \; (E_n) = \frac{\Gamma(E_n) \cdot S(\bar{R}_i, \bar{Z}_i, \bar{\theta}_k) \cdot \Psi \; (W_{R1} \; E_n)}{4 \pi \rho^2}$$

where :

$\Gamma(E_n)$ = the source strength for each group, E_n, and all other parameters were previously defined except $\Psi(W_R, E_n)$ which is described below.

Neutron Spectra Monovariant Polynomial

$$\Psi(W_R, E_n) = \exp\left[f(W_R, E_n)\right]$$

where:

$$f(W_R, E_n) = \sum_{i=0}^{4} \gamma_i (E_n) \cdot W_R^i$$

γ_i = monovariant polynomial coefficients fit to the infinite media neutron spectra data

If, $W_R > 120.0 \text{ gm/cm}^2$,

$$f(W_R, E_n) = \left[\sum_{i=0}^{4} \gamma_i (E_n) \cdot 120.0^i\right] \cdot \exp\left[-\lambda(E_n) \cdot (W_R - 120.0)\right]$$

$\lambda(E_n)$ = parameter for extrapolation of the neutron spectra data for each neutron energy, E_n

Neutron Spectra Bivariant Polynomial

$$\Psi(W_R, E_n) = \exp\left[f(W_R, E_n)\right]$$

where:

$$f(W_R, E_n) = \sum_{i=0}^{4} \sum_{j=0}^{6} \Delta_{ij} E_n^i W_R^j$$

Δ_{ij} = bivariant polynomial coefficients fit to the infinite media neutron spectra data

If, $W_R > 120.0 \text{ gm/cm}^2$,

where:

$$f(W_R, E_n) = \left[\sum_{i=0}^{4} \sum_{j=0}^{6} \Delta_{ij} E_n^i \; 120.0^j\right] \exp\left[-\lambda(E_n) \cdot (W_R - 120.0)\right]$$

Gamma Ray

The KAP VI code calculates both uncollided and collided gamma ray response at a detector point. Thecollided response is obtained from the use of a buildup factor applied to the uncollided (exponential alternation) response.

The gamma ray point kernel equation in the KAP VI code for computing the response at the detector from each source point for each gamma ray energy group, E_G is:

$$D\gamma\,(E_G) = \frac{\Gamma(E_G)\ .\ S(\overline{R}_i, \overline{Z}_j, \overline{\theta}_k)\ .\ \psi(\rho_m, E_G)}{4\pi\rho^2}$$

where: $\Gamma(E_G)$ = the source strength for each group, E_G, and all other terms were defined previously, except $\Psi(\rho_m, E_G)$ which is defined below.

Uncollided Gamma Ray Flux

$$(\rho_m, E_G) = \exp\left[-b_T(E_G)\right]$$

where:

$$b_T(E_G) = \sum_{m=1}^{M} \mu_m(E_G)\ \rho_m$$

$\mu_m(E_G)$ = the gamma ray total absorption coefficient for each material, m, and each gamma ray group, E_G.

Collided Gamma Ray Flux

$$\Psi(\rho_m, E_G) = B(\rho_m, E_G)\ .\ \exp\left[-b_T(E_G)\right]$$

where:

$$B(\rho_m, E_G) = B\left[b_T(E_G)\right]$$

or, if $b_T(E_G) > 20.0$,

$$B(\rho_m, E_G) = B(20.0)$$

and,

$$B\left[b_T(E_G)\right] = \sum_{i=0}^{3} \beta_i(E_G)\ .\ \left[b_T(E_G)\right]^i$$

The quantities, β_i, are the coefficients for the cubic polynomial fit to the infinite media buildup factor data. These values of β_i can be either input to the code or obtained from the built-in library described in Section 2.7.7. In the above equation, $b_T(E_G)$, is not allowed to exceed 20.0 mean free paths, because polynomial functions are not valid beyond this range.

The user will note that the units of μ_m (E_G) can be input as either cm^{-1} or cm^2/gm depending upon the units of ρ_m. If the library of the gamma ray absorption coefficients (see Section 2.7.7 is used in the program, the units of μ_m (E_G) are cm^2/gm.

2.7.6. Detector Response Function Description

A desirable feature of the KAPVI code is the ability to apply conversion factors to the total energy independent fast neutron detector response, the differential neutron energy detector response, and the gamma ray detector response. For example, application of the conversion factors to the gamma ray detector response could, at the option of the user, provide gamma ray output in units of: Mev/cm^2-sec, R/hr, R/hr-watt, Rads-carbon/hr, watts/gm-steel, watts/gm-aluminum, etc., all in one run on the computer.

The d tector response is calculated as the total response at a given detector from all source points in a specific source zone as follows:

$$DT_n = \sum_{\text{over all source points}} D_n$$ D_n = Total energy-independent fast neutron response

$$DT_n(E_n) = \sum_{\text{over all source points}} D_n(E_n)$$ $D_n(E_n)$ = Total diffenential fast neutron energy response

$$DT_\gamma(E_G) = \sum_{\text{over all source points}} D_\gamma(E_G)$$ $D_\gamma(E_G)$ = Total gamma ray response

where: D_n, $D_n(E_n)$, and $D(E_G)$ were previously defined for each source point.

A set of ten energy-independent conversion factors may be input to convert the quantity, DT_n, to other units; a second set of ten conversion factors for each group, E_n, may be input to convert the quantity $DT_n(E_n)$, to other units; and finally, a third set of ten conversion factors for each group, E_G, may be input to convert the quantity, $DT(E_G)$, to other units. Therefore, for each detector point calculation, a total of thirty different responses may be obtained as output data.

The equations solved in applying the conversion factors are as follows:

Albert-Welton Function

$$DT'_{n,1} = DT_n \cdot C_1$$

$$DT'_{n,2} = DT_n \cdot C_2$$

etc.

where: $C_1, C_2, \ldots, C_{10}$ = the input conversion factors, RSPA.

Differential Neutron Spectra Function

$$DT'_{n,1}(E_n) = DT_n(E_n) \cdot C_1(E_n)$$

$$DT'_{n,2}(E_n) = DT_n(E_n) \cdot C_2(E_n)$$

etc.

where: $C_1(E_n), C_2(E_n), \ldots, C_{10}(E_n)$ = each set of input conversion factors (RSPN), for each group, E_n.

Gamma Ray Function

$$DT'_{\gamma,1}(E_G) = DT_\gamma(E_G) \cdot C_1(E_G)$$

$$DT'_{\gamma,2}(E_G) = DT_\gamma(E_G) \cdot C_2(E_G)$$

etc.

where: $C_1(E_G)$, $C_2(E_G)$, ... $C_{10}(E_G)$ = each set of input conversion factors (RSPG), for each group, E_G.

The user will note that at least one set of response functions must be input for each function, DT_n, $DT_n(E_n)$, and $DT_\gamma(E_G)$. Otherwise the code will multiply by zero, and all values of DT'_n, (E_G), $DT'_n(E_n)$, and DT'_γ (E_G) will be printed as zeros.

2.7.7 Gamma Ray Library Description

Gamma ray library data or the capability to use an input library tape are included in the program to reduce tedious preparation of input data and to provide the user with latitude in specifying source gamma ray energies (e.g., a single 2.23 Mev gamma ray from hydrogen radiative capture or any of the radioisotope gamma ray source energies). The gamma ray library data consists of: 1) gamma ray mass absorption coefficient data as bivariant polynomial coefficients or tabular data as a function of element atomic number (Z) and gamma ray energy (E_G) or an input tape (logical tape unit 11) containing photoelectric and pair production data as a function of gamma ray energy (E_G) for specific elements, and 2) gamma ray buildup data as monovariant polynomial coefficients for specific materials (H_2O, Al, etc.) by type (energy, dose, energy absorption) and as a function of gamma ray energy (E_G). The calculated data requested from the library are stored internally by the code in the correct input data array.

Gamma Ray Mass Absorption Coefficient Data

Gamma ray absorption coefficients for each element can either be input to the program, or calculated from library data, or both. The program assumes the library calculated data to be the first set in the coefficient data, and the user (if using both options simultaneously) must input coefficient data at the proper addresses (see Section 2.2).

The gamma ray absorption coefficients in the library are calculated by three methods, depending on the input quantity MATL and on the atomic number of the element which is input to the program. These mass absorption coefficients are computed in units of cm^2/gm.

Method 1 ($1 \leq Z \leq 19$)

If the atomic number (Z) of the element is less than Z = 20, the program uses parabolic interpolation of tabulated data to obtain the mass absorption coefficient, μ/ρ (E_G), at energy E_G for the specified atomic number. A total of 19 sets of tabulated mass absorption coefficient data are included for Z = 1 through 19. Each set contains the 28 energy points presented in Reference 4.

Method 2 ($19 < Z \leq 92$)

If the atomic number (Z) of the element is greater than 19, an equation for ($\frac{\mu}{\rho}$ (E_G)) in the form of a bivariant polynomial is solved to obtain the mass absorption coefficient as a function of element atomic number (Z) and gamma ray energy (E_G). The mass absorption coefficient calculation follows as:

$$\left[\frac{\mu}{\rho}(E_G)\right]_m = \sum_{n=0}^{3} \sum_{g=0}^{3} \tau_{ng} (Z_m)^n \left(\frac{1}{E_G}\right)^g \qquad (2.53)$$

The τ_{ng}'s are bivariant polynomial coefficients from Reference 4 fitted over two energy ranges of 0.2 to 2.0 to 10 Mev. If the input gamma ray energy is below 0.2 Mev, or greater than 10.0 Mev, the program sets the energy equal to the limit (0.2 or 10.0 Mev) and obtains the absorption coefficient at the energy limit.

Method 3

If the input quantity MATL (See Section 2.2) is input as a negative number the mass absorption coefficient data are calculated from library data[(5)] on magnetic tape and an internal computation of the Compton scattering mass absorption coefficient data. The user provides as input the atomic numbers of specific element data on tape corresponding to the list in Table 2-4. The library data for photoelectric and pair production absorption (in units of barns/atom) are read from this magnetic tape as point values at specific energy points. This magnetic tape (which can be prepared by the GAMLEG-W[(6)] code) contains a lead binary record containing the number of sets of elemental data and each set of elemental data consists of five (5) binary records as follows: Record 1 is a title, Record 2 contains the number of energy points (< 99) in the data following, the atomic number of this element (floating point), and the atomic weight of the element. Records 3, 4, and 5 contain the energy point values, the pair production data, and the photoelectric data respectively. A logarithmic interpolation of these energy point data to the input values of E_G is performed and the mass absorption coefficient calculation follows as:

$$\left[\frac{\mu}{\rho}(E_G)\right]_m = \frac{Na}{AW_m}\left[\mu_m^{pp}(E_G) + \mu_m^{pe}(E_G) + Z_m\,\mu_s(E_G)\right]$$

where:

Na = Avogardro's number, $\left(\frac{\text{atoms}}{\text{gm-mole}} \; X_{10}^{-24}\right)$

AW_m = Atomic weight of element m, $\left(\frac{\text{grams}}{\text{gm-mole}}\right)$

Z_m = Atomic number of element m, $\left(\frac{\text{electrons}}{\text{atom}}\right)$

$\mu_m^{pp}(E_G)$ = pair production absorption coefficient at energy E_G for element m, $\frac{\text{barns}}{\text{atom}}$

$\mu_m^{pe}(E_G)$ = photoelectric absorption coefficient at energy E_G for element m, $\left(\frac{\text{barns}}{\text{atom}}\right)$

$\mu_s(E_G)$ = Compton scattering coefficient at energy E_G, $\left(\frac{\text{barns}}{\text{electron}}\right)$

Compton scattering data are calculated from the Klein-Nishina equation for the inelastic scattering of a photon with a free electron. This calculation is as follows:

$$\mu_s(E) = 0.49896\left\{\frac{1+E_0}{E_0^{\;2}}\left[\frac{2+2E_0}{1+2E_0} - \frac{\ln(1+2E_0)}{E_0}\right] + \frac{\ln(1+2E_0)}{2E_0} - \frac{1+3E_0}{(1+2E_0)^2}\right\}$$

where: $E_0 = E_G$ in units of electron rest mass, $E_0 = E_G/0.511$

Gamma Ray Buildup Factor Data

Gamma ray buildup factor data in the KAP VI code can either be input to the code as specific energy group data, or the user may calculate cubic polynomial buildup factor coefficients using a bivariant polynomial equation. The program contains a library of a single set of bivariant polynomial data (Reference 6) that can be evaluated for each gamma ray energy group. Buildup factor input data to the code is restricted to the cubic polynomial data in the variable, $b_T\ (E_G)$. The buildup of gamma ray energy is represented by a single material. Hence, the user must select a set of polynomial data which is representative of the system material composition.

The polynomial form of the buildup factor in the code is:

$$B\left(b_T(E_G)\right) = \sum_{i=0}^{3} \beta_i\,(E_G)\,.\ \left[b_T\ (E_G)\right]^i$$

If the user specifies the buildup factor library data, the control word IBILD and the input gamma ray energies, E_G, are used in computing the polynomial coefficients, $\beta_i\ (E_G)$, to be used in all buildup factc- evaluations. The values of $\beta_i\ (E_G)$ are internally computed by the code from the bivariant polynomial expressions presented in Reference 6. These bivariant polynomials have certain restrictions which the code handles as follows:

1. If the gamma ray energy is less than or greater than the applicable energy range of the bivariant polynomial data, the buildup factor coefficients $\beta_i\ (E_G)$'s are evaluated at the lower or upper limit of the range (see Table 2-2).

2. If the polynomial's applicable range (TMFP) of depth penetration, $b_T(E_G)$, in mean free paths, is different than 20.0, the program assigns a value consistent with the buildup data to be used.

3. If the bivariant polynomial data is available for two ranges of energy, the code automatically selects the correct set of data to be evaluated for each energy.

The buildup factor library data presently available in the KAP VI code is shown in Table 2.2 along with the applicable ranges of energy and depth penetration values which are built into the code. The input values of IBILD that will select the desired data are also presented.

The bivariant polynomials solved by the code to obtain the buildup factor coefficients, $\beta_i (E_G)$, are:

$$\beta_i (E_G) = \sum_{i=0}^{J} \xi_{ij} (Z_m)^i$$

or

$$\beta_i (E_G) = \sum_{i=0}^{J} \xi_{ij} \left(\frac{1}{Z_m}\right)^i$$

The program automatically selects the proper form of the polynomial as indicated by the input values of IBILD, E_G, and Z_m.

2.7.8 Detector Response in a Source Zone

A basic difficulty with the point kernel method is the calculation of the detector response when the detector is located in, or very close to, the source zone. This difficulty arises when the denominator in the kernel approaches zero, i.e., in the equation, $\phi = \psi/4\pi \rho^2$, if the quantity ρ (the distance from the source point to the detector point) is a very small number, the function, ϕ, approaches infinity, and yields misleading, if not erroneous results. To obtain a meaningful (or valid) detector response when the source-detector must be handled with extreme caution. The preceding discussion applies even when the option (described in this section) is used.

To compute the analytical response at the detector within a source zone using this option, the control word ISCP must be input as the composition number of the source zone of interest, and SMFP, which is the total mean free path of the source zone composition (ISCP), must be input.

This option, which is provided to the KAP VI code user, should be applied judiciously. Note that the option applies only to a gamma ray calculation.

The program then solves the following equation:

$$\mu_s (E_G) = \sum_{m=1}^{M} \left[\frac{\mu}{\rho} (E_G)\right]_m \theta_{m, \, ISCP}$$

where:

$\mu_s (E_G)$ = the macroscopic gamma ray absorption coefficient (cm^{-1}) for the source zone of interest for each energy group, G.

$\left[\frac{\mu}{\rho} (E_G)\right]_m$ = the microscopic gamma ray absorption coefficient (cm^2/gm) for each energy group, G.

$\theta_{m, \, ISCP}$ = the density (gm/cm^3) of each material, m, in the composition, ISCP.

In the above equation, $\left[\frac{\mu}{\rho} (E_G)\right]_m$, can be input as macroscopic data (cm^{-1}), if $\theta_{m, \, ISCP}$ are input as dimensionless volume fractions.

Next, the dimensionless quantity, ν, is calculated for each source point as:

$$\nu = \mu_s (E_G) \cdot \rho$$

where ρ is the total distance (cm) from a particular source point to the detector point, and $\mu_s(E_G)$ is defined above.

For each source-detector path calculation, ν is tested against the input quantity, SMFP. If, $\nu \geq$ SMFP, the code calculates the usual attenuation function. If $\nu <$ SMFP, the code solves the following equation as the gamma ray attenuation function, $D_\gamma (E_G)$, at the detector for each group, G:

$$D_\gamma(E_G) = \frac{B(E_G, SMFP) \cdot \bar{S}\,(E_G) \cdot \left(1 - \exp(-SMFP)\right)}{\frac{4}{3}\pi\left(\frac{SMFP}{\mu_s(E_G)}\right)^3 \cdot \left(\mu_s(E_G)\right)}$$

where:

$B(E_G, SMFP)$ = the buildup factor for each group, G, computed as: $\beta_o + \beta_1$ SMFP $= \beta_2\,(SMFP)^2 + \beta_3\,(SMFP)^3$

$\bar{S}\,(E_G)$ = the source (e.g. watts or fissions per second) for the sphere whose radius is defined as ν for each group, G.

$\frac{4}{3}\pi \frac{SMFP}{\mu_s(E_G)}^3$ = the volume, cm^3, of the sphere, calculated for each group, G.

The quantity, $\bar{S}(E_G)$, is calculated as the summation of the source for all source points within radius, ν. The solution of the above equation is the response at a detector point located at the center of a spehrical source of ν mean free paths in radius, q.

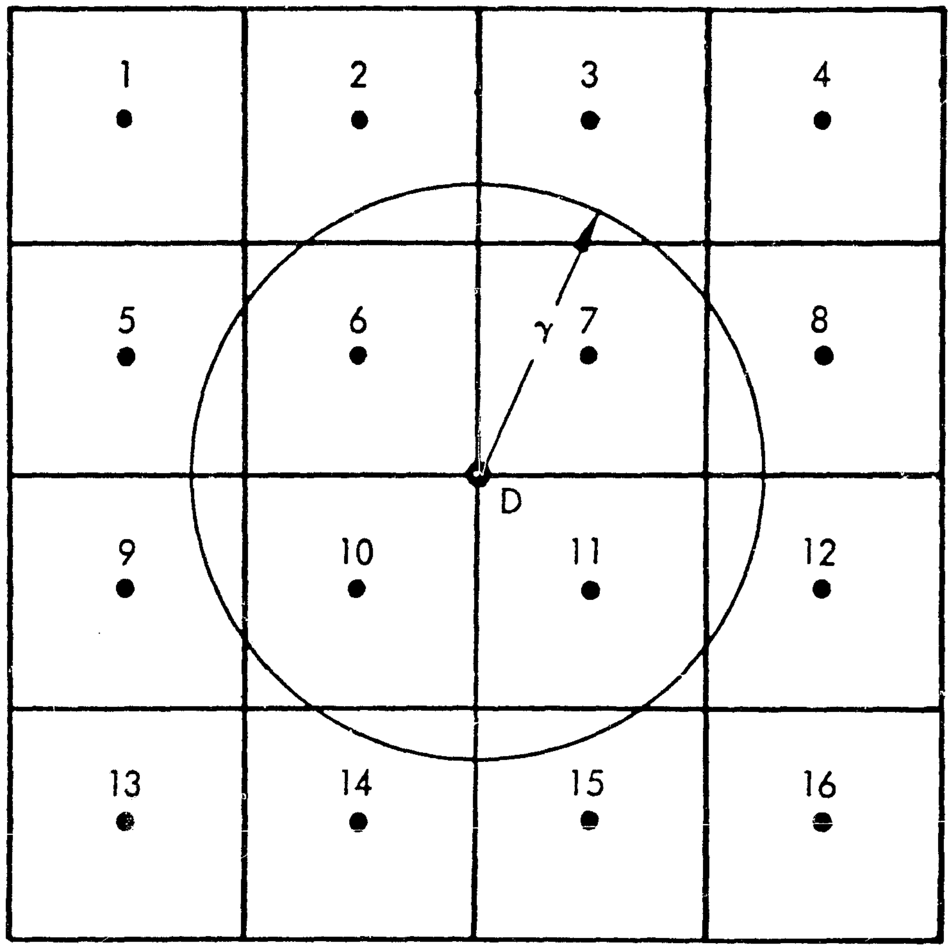
The quantity, $D_\gamma\,(E_G)$, is added to the detector response calculated for all the source points external to the sphere. Two examples are given to illustrate some problems associated with the option.

1. Figure 2-4 shows an r, z plane cut through an "exclusion" shphere of radius, ν. A typical source point mesh is also shown in Figure 2-4. The detector point is located at D, the center. For this example, attenuation functions for source points, 1-4, 5, 8, 9, and 12-16 would be calculated by the usual KAP VI equations. The source strengths for the volume elements surrounding points 6, 7, 10, and 11 would be used in the "sphere" option.

One can observe that a part of the volume surrounding points 6, 7, 10, and 11 is outside the sphere, but are included in the total source calculations for the sphere; and, that part of the element volume surrounding point no. 8 (for example) which actually lies within the sphere, is not included in the total source for the sphere.

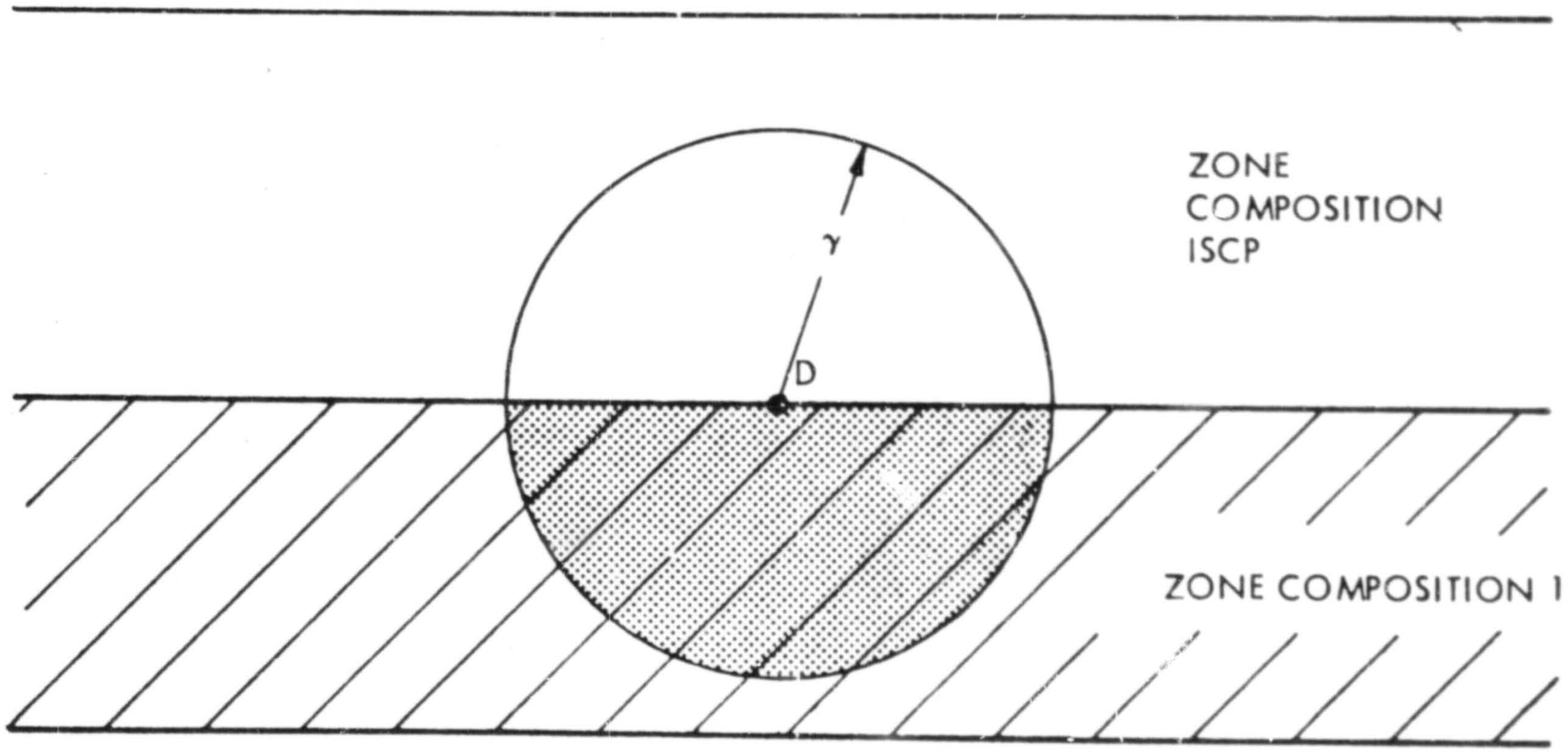
These approximations are part of the option, and introduce some uncertainties in the answer.

2. Figure 2-5 shows a sphere overlapping two regions having different composition numbers. The zone with composition No. 1 is not a source region. But that portion of the sphere which extends into the region (shown by the shaded area) does, in fact, have a source strength associated with it. Hence, a calculation using this option (as coded) when the detector is near the boundary of a source region, introduces uncertainties in the answer.



611855-51B

Figure 2-4. Example of "Exclusion" Sphere Option



611855-52B

Figure 2-5. Example of "Exclusion" Sphere Option

3.0 SCAP CODE

SCAP is a point kernel code employing energy dependent single or albedo-scatter methods to calculate the radiation level at a detector point located within or outside a complex scattering geometry describable by a combination of quadratic surfaces. The code evaluates the material thickness and scatter points in materials intercepted along lines-of-sight from an anisotropic energy dependent source point. The material thicknesses (or path lengths) to each point is used in an exponential attenuation function to calculate the radiation level at each scatter point.

Three options exist in the treatment of particle scattering to a detector point. Photon scattering at the scatter point to the detector point can be treated as a Compton scatter event using the differential form of the Klein Nishina for the inelastic scattering of a photon with a free electron, or as a simple albedo scatter event at the surface of a geometric zone. Neutron scattering at the scatter point to the detector point can be treated only as an albedo scatter event at the surface of the geometric zone.

The attenuation function for the scattered particle (photon or neutron) on the scatter leg to the detector point is an exponential attenuation function with a buildup factor to account for multiple scatter on the scatter leg for photons only.

The code handles a series of anisotropic energy dependent point sources with the anistropy of the point sources represented as the pointwise variation of flux levels on a spherical detector (meridian ring).

Specific desirable features which have been incorporated in the SCAP code are:

(1) Input data preparation has been simplified to allow minimum input for running "stacked" cases.

(2) A routine is included in the code to calculate gamma ray cross sections (mass absorption coefficients) for elements as a function of input gamma ray energy from magnetic tape data and internal calculations.

(3) A routine is included in the program to calculate the cubic polynominal coefficients for buildup factors as a function of scattered gamma ray energy from a library of bivariant polynominal data.

(4) A routine is included which will interpolate a closely-spaced pointwise source distribution as a function of polar angle to a source polar angle mesh description more amenable and economic to single- or albedo-scatter point kernel calculations.

(5) A method is included which calculates and normalizes point source strengths.

(6) Input data are checked for consistency to eliminate many erroneous calculations that can occur if input data for a problem is incomplete.

(7) The code has the capability to calculate fluxes and dose rates at a detector point for each source point and calculate the energy disposition of gamma rays in the scatter geometry.

(8) The code is written in flexible dimensioning so that there exists no fixed limits on the size of geometry, energy, or source points except a restriction on the sum of all arrays.

(9) An option is included for calculating the flux at a detector located within a gamma ray scatter region. This option circumvents the numerical difficulties introduced by the "inverse square law" when a scatter point is too close to the detector.

(10) Options are included to accept KAP VI and MAP punched card data as input source data.

Section 3.2 gives a description of the required input data for the SCAP code. Section 3.3 gives a detailed input data information for specific data arrays. Section 3.4 briefly describes problem setup information, including tape assignments, running time and a sample problem. Section 3.5 gives a description of the SCAP output data. Section 3.6 describes the code logic and Section 3.7 provides a description of the numerical method of solving the single- or albedo-scatter point kernel method.

3.1 COMPUTER CODE SYNOPSIS

1. Name: SCAP[1]
2. Computer: The code is operational on the MSFC UNIVAC 1108 computer system under EXEC8 monitor system control.
3. Nature of Physical Problem Solved:
   SCAP solves for radiation transport in complex geometries using the single- or albedo-scatter point kernel method. The code is designed to calculate the neutron and gamma ray radiation level at detector points located within or outside a complex radiation scatter source geomety. Geometry is describable by zones bounded by intersecting quadratic surfaces with a maximum of six boundary surfaces per zone. Anisotropic point sources are describable as pointwise energy dependent distributions as a function of polar angle on a meridian. The attenuation function for gamma rays is an exponential function on the primary source leg and the scatter leg with a buildup factor approximation to account for multiple scatter on the scatter leg. The neutron attenuation function is an exponential function using neutron removal cross sections on the primary source leg and scatter leg.
4. Method of Solution: A point kernel method using a anistropic point source representation is used, line-of-sight material attenuation and inverse square spatial attenuation between the source point and scatter points and the scatter points and detector point is employed. A direct summation of individual point source results is obtained.
5. Restrictions on the Complexity of the Problem: The SCAP code is written in complete flexible dimensioning so that no restrictions are imposed on the number of energy groups or geometric zones. The geometric zone description is restricted to zones defined by a maximum of six boundary

surfaces with each surface defined by the general quadratic equation or one of its degenerate forms. The only restriction in the code is that the total data array dimension must be less than the dimension of blank COMMON.

6. Typical Running Time: The SCAP code computes approximately 50 source point-to scatter point-to detector point calculations per second on the UNIVAC 1108 computer. This running time is essentially independent of the number of energy groups and is only dependent upon the calculation of geometry dependent data.

7. Unusual Features of the Code: The use of a generalized method of determining scatter point densities based on the electron density of the media encountered on a line-of-sight as well as the use of a generalized spherical geometry integration technique over scatter zones defined in a complex geometry are unique features of the code.

8. Related or Auxiliary Codes: Gamma ray absorption coefficients (cross sections) may be supplied by magnetic tape from the GAMLEG-W[2] code. Neutron and gamma ray point source distribution data can be supplied on punched cards from the KAP VI and MAP codes as anisotropic energy dependent source data.

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

10. References:

1. R. K. Disney and S. L. Zeigler, WANL-PR(LL)-034, Volume 6 "Point Kernel Techniques", August 1970.
2. 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.

3.2 INPUT DATA DESCRIPTION

3.2.1 Input Format

The input data for the SCAP code are divided into the following three data sets:

1) Overall problem storage allocation
2) Overall problem title and parameters
3) Problem geometry, source, and detector 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 and real data on formatted cards in data fields of 12 columns each. This set of data is always required as input to a SCAP 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.

The remaining data set 3 of a SCAP problem input is 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 SCAP (FIDO)* format capability 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 may be entered in the standard SCAP or one of two non-standard format capabilities.

The non-standard 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 a data array should include 117 entries, the punched card input for the array

---

*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.

**"right adjusted" means that the least significant digit of an integer number is at the extreme right of the field.

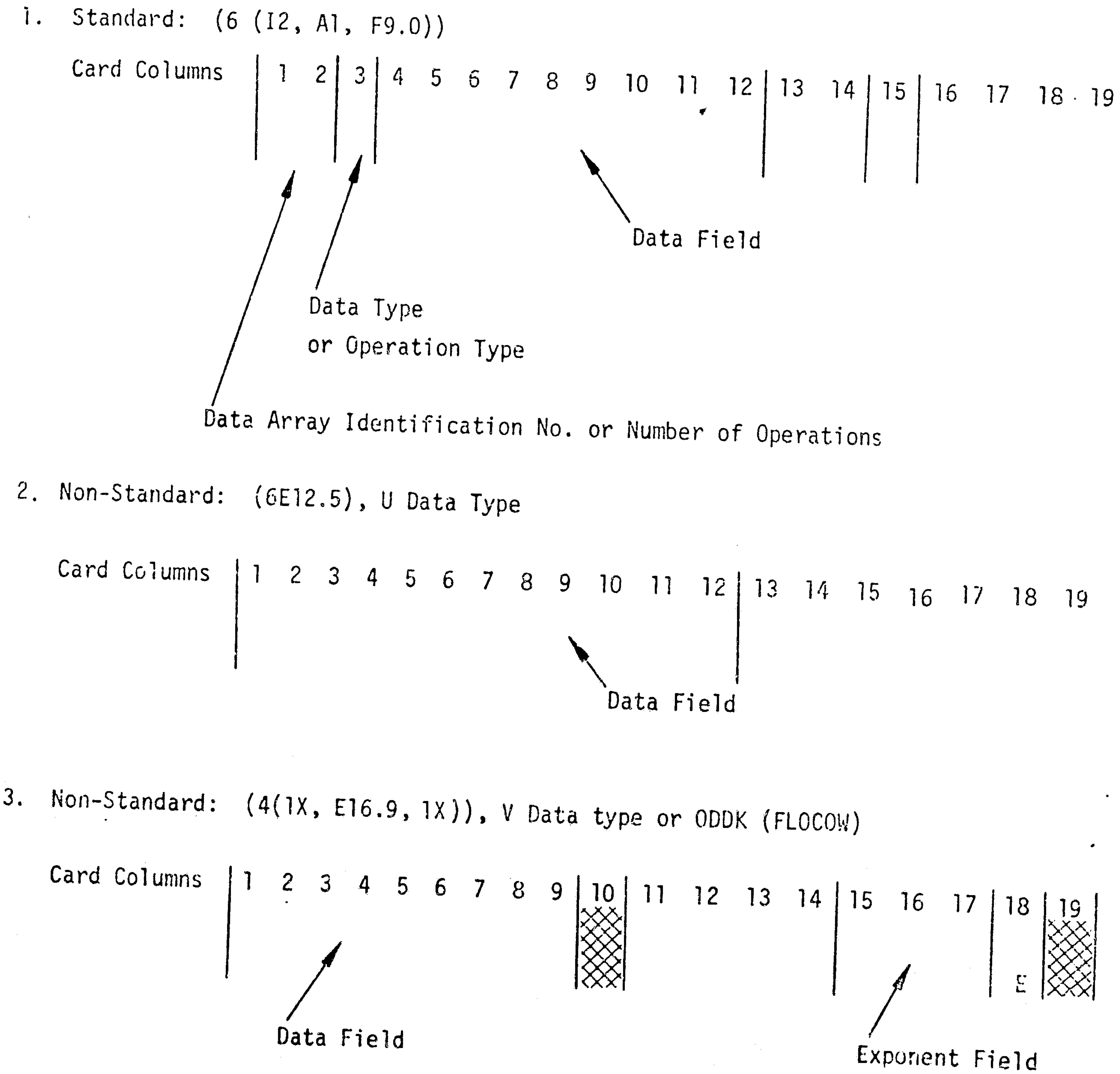


Figure 3.1. SCAP Input Formats

would be 19 full cards (6 values/card) and a final card of three entries using the U format. SCAP, using this non-standard capability, would skip the last three fields of the last card and commence reading at the first data field of the next card.

In the standard SCAP 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 (i.e., 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 (i.e., 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 datacard.

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 (i.e., 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 (i.e., 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 enteres 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 (contain the 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 SCAP

1) Floating point zeros must be written as 0. or 0.0; a.0 or -.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.

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 at the extreme right of the nine column subfield.

3.2.2 Input Data Instructions

This section is to be used as a guide in preparing problem input data for the SCAP 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 brackets 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 set 3 and no T card is entered after data sets 1 and 2.

TABLE 3-1

INPUT DATA INSTRUCTIONS FOR SCAP CODE

DATA SET 1 - OVERALL PROBLEM DATA STORAGE ALLOCATION

Card Type	FORTRAN Format	Card Column	Variable Name	Description
1	6X, 16	7 - 12	LIM1	The number of core memory storage locations to be allocated for problem data storage. On the MSFC UNIVAC 1108 the value of LIM1 is set by the size of the blank common array size of 35,000.

DATA SET 2 - OVERALL PROBLEM TITLE AND PARAMETERS

Card Type	FORTRAN Format	Card Column	Variable Name	Description
2	12A6	1 - 72	TITLE	Problem descriptive title
3	6I12	---	---	Source, energy, and cross section specifications
		1 - 12	NG	No. of energy groups in problem final output data.
		13 - 24	N6	No. of energy groups in problem source input data
		25 - 36	NA	No. of polar angles or detector points in problem source input data. If NA is negative, KAP VI code punched card output is input by energy group and polar angle. If NA is positive, MAP code punched card output is input by polar angle and energy group.

TABLE 3-1 (Continued)

DATA SET 2 - OVERALL PROBLEM TITLE AND PARAMETERS (continued)

Card Type	FORTRAN Format	Card Column	Variable Name	Description
				NOTE: If a SCAP problem is a change case from the previous problem in the input stack then NA must be a positive integer.
		37 - 48	NC	No. of energy points in the pointwise absorption cross section data.
		49 - 60	NE	No. of elements in the zone composition-element table.
		61 - 72	NM	No. of compositions in the zone composition-element table.
4	6I12	---	---	---
		1 - 12	NZ	No. of zones in problem.
		13 - 24	NB	No. of boundary surfaces in problem.
		25 - 36	NR	Number of initial source rays emanating in polar angle from anisotropic point source. If NR is positive then the polar angle range is subdivided equally into NR intervals. NOTE: If NR is negative (-) then the user may specify by the input array ANG (28*) the polar angle limits defining the source rays.
		37 - 48	NT	Order of integration (trapezoidal rule) in azimuthal angle of anisotropic point source. NOTE: If NT = 1, the 2π symmetry

TABLE 3-1 (Continued)

DATA SET 2 - OVERALL PROBLEM TITLE AND PARAMETERS (continued)

Card Type	FORTRAN Format	Card Column	Variable Name	Description
				condition for an on-axis point source and detector point is applied.
		49 - 60	NSZO	Most probable zone which contains the anisotropic point source.
		61 - 72	NL	Library option 1 - use GAMLEG-W library data tape on tape unit 11 to generate gamma rays absorption (photoelectric plus pair production) cross section data. 0-enter cross section data as the input data array SIG(27*) and material electron density as the input data array ZOM(26*).
5	6I12	---	---	---
		1 - 12	NPT	Number of source points in problem. (NPT $\geq$ 1)
		13 - 24	NBT	Type of buildup desired (See Table 2-2 for available library data).
		25 - 36	NTY	Type of Scatter Technique 0/1, Single Scatter/ Albedo Scatter.
6	6E12.5	---	---	---
		1 - 12	TH1	Lower limit in polar angle at which source rays will emanate from anisotropic point source.

TABLE 3-1 (Continued)

DATA SET 2 OVERALL PROBLEM TITLE AND PARAMETERS (continued)

Card Type	FORTRAN Format	Card Column	Variable Name	Description
		13 - 24	TH2	Upper limit in polar angle at which source rays will emanate from anisotropic point source.
		25 - 36	TT1	Lower limit in azimuthal angle at which source rays will emanate from anisotropic point source. (Used as lower limits of trapezoidal rule integration).
		37 - 48	TT2	Upper limit in azimuthal angle at which source rays will emanate from anisotropic point source. (Used as upper limit of trapezoidal rule integration). NOTE: TT1 and TT2 can be used to perform scatter calculations in only a limited range of the azimuthal angle average.
7	6E12.5	---	---	---
		1 - 12	RM	Radius of meridian ring at which anisotropic point source data is defined.
		13 - 24	DED	Electron path length (electrons/cm^2 x 10^{24}) per scatter point used to determine position and frequency of scatter points on line-of-sight through the scatter lines.

TABLE 3-1 (Continued)

DATA SET 2 OVERALL PROBLEM TITLE AND PARAMETERS (continued)

Card Type	FORTRAN Format	Card Column	Variable Name	Description
				NOTE: DED is used only in a single scatter calculation.
		25 - 36	RP	Radius of sphere which contains all scatter points in the problem. RP must be greater than any possible line-of-sight through the geometry.
		37 - 48	SCALE	Multiplicative factor applied to all source data for normalization.
		49 - 60	RX	Exclusion radius on primary leg. NOTE: No single-or albedo-scatter points are allowed within a radius RX of any source point.

TABLE 3-1 (Continued)

DATA SET 3 - PROBLEM GEOMETRY, SOURCE, AND DETECTOR DATA

Data Set Number	Format Symbol	Variable Symbol	Description
1	$	NBZ	No. of boundaries per zone. NOTE: If NBZ is negative then the zone is an outside zone and no further geometry calculations beyond this zone to the detector are performed. /NZ values/
2	$	NBD	Boundary numbers for each surface of a zone, six numbers per zone must be entered, i.e., one card per zone, with boundaries not used to define this zone, specified as integer zero (0). /6 x NZ values/ NOTE: Ambiguity indices for boundaries of zones must be assigned by user as + or - the boundary number. Ambiguity indices are assigned as negative for boundaries which are in a negative direction in relation to the ray leaving the zone and crossing the boundary.
3	$	NTR	Zone numbers entered upon crossing each boundary of a zone, six numbers per zone, i.e., one card per zone, entered in the same order as the NBD numbers with zone numbers not used to define the zone specified as integer zero (0). /6 x NZ values/
4	$	NBE	Equation number for each boundary surface. Boundary equations defined in Table 3.2./NB values/

TABLE 3-1 (Continued)

DATA SET 3 - PROBLEM GEOMETRY, SOURCE, AND DETECTOR DATA (continued)

Data Set Number	Format Symbol	Variable Symbol	Description
5	* or U	XO	Coefficients for boundary surface equations / NB values /
6	* or U	YO	Coefficients for boundary surface equations / NB values /
7	* or U	ZO	Coefficients for boundary surface equations / NB values /
8	* or U	AO	Coefficients for boundary surface equations / NB values /
9	* or U	BO	Coefficients for boundary surface equations / NB values /
10	* or U	CO	Coefficients for boundary surface equations / NB values /
11	* or U	DO	Coefficients for boundary surface equations / NB values /
12	* or U	ENC	Energy values for cross section data / NC values /
13	* or U	ZOE	Electrons/atom for each element in zone composition/element table. NOTE: If NL = 1 then values of ZOE are used to obtain data from tape unit 11. See Table 2-4. /NE values/

TABLE 3-1 (Continued)

DATA SET 3 - PROBLEM GEOMETRY, SOURCE, AND DETECTOR DATA (continued)

Data Set Number	Format Symbol	Variable Symbol	Description
14	* or U	COM	Density (gm/cm^3) for each element in each composition by element and composition. / NE * NM values /
15	$	NMZ	Number of composition in each zone. / NZ values /
16	* or U	ENS	Energy values anisotropic point source data at meridian ring. / NS values /
17	* or U	ENG	Energy group limits for scattered results at the detector point. / NG + 1 values /
18	* or U	ANS	Polar angles corresponding to the meridan ring data used to describe the anisotropic point source. / NA values /
19	* or U	SOS	Anisotropic point source data obtained at a meridian ring by angle and group (MAP punched card input) or group and angle (KAP VI punched card input for each source point. Input order defined by sign of input quantity NA in DATA SET 2. / NA * NS * NPT or NS * NA * NPT values /

TABLE 3-1 (Continued)

DATA SET 3 - PROBLEM GEOMETRY, SOURCE, AND DETECTOR DATA (continued)

Data Set Number	Format Symbol	Variable Symbol	Description
20	* or U	XP	Anisotropic point source coordinates, (X_p, Y_p, Z_p), for each source point. / 3*NPT values /
21	* or U	XD	Detector point coordinates, (X_d, Y_d, Z_d). /3 values /
23	* or U	BETA	Group dependent albedo in order of decreasing energy based on source energies, ENS. / NS values /
24	$	NALB	Type albedo scatter by source energy group if NTY = 1, 2/3, neutron/ photon. See Table 3.3 for options definition. / NS values /
25	* or U	DØC	Dose at conversion factor by source energy group. Required only if NTY = 1 and NALB = 1 or 2.

NOTE: ZOM(26*) and SIG(27*) are required only if NL = 0

Data Set Number	Format Symbol	Variable Symbol	Description
26	* or U	ZOM	Electrons/cm^3 for each composition by zone
27	* or U	SIG	Gamma absorption cross section (σ_{pp} plus σ_{pe}) corresponding to energy values, ENC and for each composition.

TABLE 3-1 (Continued)

DATA SET 3 - PROBLEM GEOMETRY, SOURCE, AND DETECTOR DATA (continued)

Data Set Number	Format Symbol	Variable Symbol	Description
28	* or U	ANG	(If NR is negative) Polar angle mesh lines defining the angular limits or bounds of the polar angle intervals of the anisotropic point source. The source rays emanate from the midpoint of these intervals. / NR + 1 values /
T	- - -	- -	Terminate card required at the end of DATA SET 3 only.

TABLE 3-2

SCAP BOUNDARY EQUATION NUMBERS AND EQUATIONS

Boundary Equation Type (NEQBD)	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	$(x-X_o)^2 + (y-Y_o)^2 + D = 0.0$	X_o, Y_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	$A(x-X_o)^2 + B(y-Y_o)^2 + C(z-Z_o)^2 - D^2 = 0.0$	$A, B, C, X_o, Y_o, Z_o, D$
9	$(x-X_o)^2 + (y-Y_o)^2 - D^2 = 0.0$	X_o, Y_o, D

TABLE 3-3

SCAP ALBEDO SCATTER FORMULAE

Type, NALB	Type of Particle	Albedo Equations
1	Neutron	$\alpha(E) = \beta(E)\left(\cos^{(2/3)}\theta_o\right)\cos\theta$
2	Neutron	$\alpha(E) = \beta(E)\left(1.625 - 0.625\cos^{(2/3)}\theta_o\right)\cos\theta$
3	Photon	$\alpha(E) = \beta(E)$

where: $\alpha(E)$ = the albedo (fraction of particles scattered) of particles incident at angle θ_o relative to the normal to the surface.

$\beta(E)$ = the albedo for particles normally incident and reflected from the surface.

3.2.3 Problem Size Determination

To determine the number of core storage required for data of a given problem, the expression below should be evaluated. This will provide the value of the required input parameter, LIM1, on card 1 of data set 1. For a SCAP problem to run successfully, the input value of LIM1 must be equal to or greater than the calculated value of LAST. All quantities in the expression below are required input quantities discussed in Section 3.2.2.

SCAP flexible dimension data storage requirements

$$\begin{aligned} LAST = {} & NZ \cdot (28 + 2 \cdot NG) + 8 \cdot NB \\ & + NC \cdot (2 + NM) + NE \cdot (NM + 1) \\ & + NS \cdot (6 + 2 \cdot NPT \cdot |NA| + |NR|) \\ & + NG + |NA| + 6 \cdot NPT + NM\,(4 + NPT) \\ & + 2 \cdot |NR| + 59 \end{aligned}$$

3.3 DETAILED INPUT DATA INFORMATION

The input data requirements for the SCAP code is described in Section 3.2. In a number of areas, input data preparation guidelines in setting up problems can be defined. This section describes in detail the options available to the user.

3.3.1 Zones and Boundary Surfaces

The required input geometry data for the SCAP code are described in DATA SET 4 of Section 3.2. The use of these data in the SCAP calculation is described in Section 3.7. 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 SCAP 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 SCAP 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 required in the SCAP input data. 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 than or equal to 1 and less than or equal to NZ. To minimize the ray trace geometry calculation time, the user should enter the zone entered on 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).

3.3.2 Special Geometry Input

The SCAP code contains options for the arbitrary specification by the user of "black" absorber zones, scatter zones, or non-attenuating zones on the source leg. These options are as follows:

1) "Black" absorber zones are zones at which the source leg calculation is terminated. This option is specified in the input by describing the value of the input quantity, NTR, for the first boundary of the "black" zone as a negative number. If the radius of the zone entry point is greater than the input value of the point source exclusion radius, RX, then the source leg calculation is terminated. This method is a convenient method to restrict scatter to a set of geometric zones within a large number of scatter zones.
2) Scatter zones are specified in the geometry input description by specifying the zone material as a positive number. The input of a negative zone material value (NMZ) will result in no scatter events in the zone.
3) Non-attenuating zones on the source leg are defined as any zone which is internal to the radius of a pseudo-sphere of radius, RX. This is an input value and is provided to allow scatter calculations in geometries with the radiation source geometry (e.g., a reactor) included in the geometry by represented as a point source by a set of meridian ring flux values.

3.4 PROBLEM SETUP INFORMATION

The setup of a SCAP code problem is described in this section with a sample problem setup and input punched card listing in Section 3.4.4. This section is intended to define the deck setup or the MSFC UNIVAC 1108 computer system. The MSFC version of the SCAP code resides on a production tape and is used by loading the code from tape with control cards preceding the input deck. The use of tape or disk files, running time, and error messages are described in the following sections.

3.4.1 Tape Assignments

The SCAP code requires a maximum of four magnetic tape or disk files for a specific problem. For a majority of problems only three files are required. The file assignments are as follows:

Tape 5	Input Disk
Tape 6	Output Disk
Tape 7	Punched Output Disk
Tape 11	Cross Section Library input Tape / Required only if NL = 1/

The Tape 11 input tape is the tape produced by GAMLEG-W and contains the pair production and photoelectric pointwise cross section data for elements in the element/composition table specified as SCAP input (see Section 3.2.2).

3.4.2 Running Time

The required running time for a given SCAP problem on the MSFC UNIVAC 1108 computer is mainly dependent upon the number of source points and the number of scatter points in the geometric zones. The estimate of the required CPU time is obtained by estimating the total number of source point-to-scatter point-to detector point calculations for each source point. The number of scatter points in a geometric model is calculated internally based on the electron density in the zones and the line-of-sight distance through each zone. The code performs approximately 50 single or albedo scatter calculations per second in a geometric model.

The total running time for a SCAP problem is estimated as:

$$t(\text{CPU seconds}) = \frac{NPT\ (NT + 1)^{*}\ NR\ {*}\ N_s}{50}$$

where: NPT is the number of source points in the SCAP problem,

NT is the number (or order of the azmuthial angle integration)

NR is the number of polar angle source rays

N_s is the total number of scatter points in all zones for each source ray.

3.4.3 Error Messages

A number of SCAP code generated error messages may be encountered in running a SCAP problem. These messages are primarily due to the incorrect problem input. The error messages are generally self-explanatory.

Message	Explanation
Data storage requirements and limits . . . x,y.	If x > y, the code terminates. This implies the problem is too large for available core storage or input value LIM1 is incorrect.
Geometry error - zone.... , bnd ... bnd number..... equation number , coordinates x = ... , y = .. , z = ...	A boundary equation number NBE ≤ 0 or NBE > 9. Check NBZ, and NBD arrays for consistency.
Geometry error - zone... , boundary..... , distance..... , coordinates (x, y, z)	A boundary crossing on the line-of-sight cannot be found. Check location of the source point and detector point with relation to geometry description.
"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.

3.4.4 Sample Problem Input

A sample problem for the SCAP code has been included in this section to illustrate the flexibility of the input data formats and the problem deck setup. The sample problem geometry is a point source on the axis and below a hydrogen propellant tank. A detector point is on the axis and above the tank. The propellant tank geometry is described in Volume 1 of this report. The tank geometry is a cylindrical center portion with an elliptic tank top and a conical tank bottom. Source input data are from punched cards provided by the KAP VI code (see Section 2.0). The calculation performed by this problem is a single-scatter calculation to calculate the dose rate at the top of the propellant tank due to an anisotropic point source representing a nuclear rocket nuclear subsystem. A listing of the sample problem input deck is in Table 3-4.

3.5 DESCRIPTION OF OUTPUT

Output data from the SCAP code consists of the printed output of the input data, and the calculated results. The printed output from the sample problem listed in Table 3-4 is presented in Table 3-5.

The printed output of the SCAP code is:

1) The title card and a listing of the input data of DATA SETS 1 and 2,

2) The data storage requirements and limits (LIM1) for the problem,

3) The FIDO subroutines edit of reading all input data arrays consisting of the type of format, the array number, and the number of entries input. Error messages described in Section 3.4.3 are printed.

4) If the input quantity NL = 1, a tabulation describing the microscopic cross section data read from the input data tape on tape with 11 (if NL = 1),

5) An organized printout of input data consisting of the geometry data, cross section energy points, atomic number of element data (electrons per atom), electron density by zone material (electrons per cm^3), and zone material compositions,

TABLE 3-4 SAMPLE PROBLEM CARD INPUT FOR THE SCAP CODE

```
LIM1=    5000
 MSFC SAMPLE PROBLEM - 200 INCH SEPARATION - KAP MERIDIAN RING DATA
           13          13          -11          30          10          10
           22          21           25           1           1           1
            1           1            0
 0.0         25.311      0.0          180.0
 914.4         6.0         10000.0      1.0          300.0
 1$
            4           3            3           2           3           4
            4           4            3           3           3           4
            4           4            3           2           3           3
            4          -2           -1          -2
 2$
           -1          21            5          -2           0           0
            2           5           -3           0           0           0
            3           5           -4           0           0           0
            4           5            0           0           0           0
           -5          15            6           0           0           0
           -5          16            8         -15           0           0
           -5          17            8         -16           0           0
           -5          21            8         -17           0           0
           -6          15            7           0           0           0
           -7          15            8           0           0           0
           -8          18            9           0           0           0
           -8          19           10         -18           0           0
           -8          20           10         -19           0           0
           -8          21           10         -20           0           0
           -9          18           10           0           0           0
          -10          11            0           0           0           0
          -10          12          -11           0           0           0
          -10          13          -12           0           0           0
          -10          21           14         -13           0           0
          -14          21            0           0           0           0
          -21           0            0           0           0           0
           21           1            0           0           0           0
 3$
           22          21            8           2           0           0
            1           7            3           0           0           0
            2           6            4           0           0           0
            3           5            0           0           0           0
            4           6            9           0           0           0
            3           7           11           5           0           0
            2           8           13           6           0           0
            1          21           14           7           0           0
            5           6           10           0           0           0
            9           6           11           0           0           0
           10          12           15           0           0           0
            6          13           17          11           0           0
```

TABLE 3-4 (Continued)

	7	14	18	12	0	0
	8	21	19	13	0	0
	11	12	16	0	0	0
	15	17	0	0	0	0
	12	18	16	0	0	0
	13	19	17	0	0	0
	14	21	20	18	0	0
	19	21	0	0	0	0
	1	0	0	0	0	0
	21	1	0	0	0	0
4$						
	6	8	8	8	6	6
	6	6	6	6	8	8
	8	6	2	2	2	9
	9	9	9			
7*						
	0.0	3R 844.54	6R 0.0	3R 2409.84	0.0	-161.90
	-163.5	-183.1	F 0.0			
8*						
	1R 0.0	3R 1.0	6R 0.0	3R 1.0	1R 0.0	3R 1.0
	F 0.0					
9*						
	1R 0.0	3R 1.0	6R 0.0	3R 1.0	1R 0.0	3R 1.0
	F 0.0					
10*						
	0.0	3R 1.0	6R 0.0	2.109	2.108	2.088
	0.0	3R-.0717972	F 0.0			
11*						
	-1000.0	261.54	256.46	256.04	776.97	898.50
	1288.50	1655.84	2188.50	2409.84	487.26	487.68
	492.76	2756.00	0.0	0.0	0.0	487.26
	487.68	492.76	1000.0			
12U						
	10.0	8.0	7.0	6.0	5.0	4.0
	3.0	2.5	2.0	1.5	1.0	0.9
	0.8	0.7	0.6	0.5	0.4	0.35
	0.3	0.25	0.2	0.15	0.1	0.08
	0.07	0.06	0.05	0.04	0.03	0.02
13U						
	1.0	6.0	7.0	8.0	13.0	16.0
	24.0	25.0	26.0	82.0		
14U						
	.00241	.055	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0		
	0.0	0.0	0.0	0.0	2.7	0.0
	0.0	0.0	0.0	0.0		
	.07	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0		

.00088	0.0	0.0	0.0	0.0	0.0	
0.0	0.0	0.0	0.0			
.0101	.0484	.0323	.1425	0.0	.0582	
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0	0.0	0.0	
0.0	0.0	0.0	11.35			
.000011	0.0	.00028	.000404	0.0	0.0	
0.0	0.0	0.0	0.0			
.0387	.3642	.0283	.1294	0.0	0.0	
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0	0.0	0.0	
0.0	0.0	0.0	0.0			
0.0	0.0	0.0	0.0	.072	0.0	
0.0	0.0	0.0	0.0			
15$						
	9	1	2	3	3	2
	1	9	4	4	4	2
	1	9	4	4	2	1
	9	9	9	9		
16U						
8.5	7.25	6.5	5.5	4.5	3.5	
2.8	2.5	2.2	1.50	1.0	0.7	
0.3						
17U						
10.0	7.5	7.0	6.0	5.0	4.0	
3.0	2.6	2.4	1.8	1.35	0.9	
0.4	0.02					
18U						
0.0	10.2631	12.5781	14.5337	15.4206	17.8242	
19.2655	20.6097	23.0739	24.2168	25.3111		
19U						
5.08435E-10	5.99838E-11	3.51039E-10	3.79753E-10	9.66830E-10	1.18632E-09	
5.10893E-10	7.34021E-10	5.42922E-10	5.62789E-10	2.56095E-10	2.09401E-10	
1.41040E-11						
7.68543E-10	7.33622E-11	4.49073E-10	4.28143E-10	1.08863E-09	1.25515E-09	
5.32762E-10	7.21633E-10	5.29995E-10	8.16192E-10	2.48061E-10	1.90839E-10	
2.12592E-11						
8.35503E-10	7.60160E-11	5.23716E-10	4.35960E-10	1.10666E-09	1.26950E-09	
5.32227E-10	7.20824E-10	5.19774E-10	9.07994E-10	2.45092E-10	1.84491E-10	
2.57884E-11						
8.76581E-10	7.70827E-11	5.91573E-10	4.35708E-10	1.10081E-09	1.25875E-09	
5.18619E-10	7.10921E-10	4.97909E-10	9.58278E-10	2.36930E-10	1.76545E-10	
2.86881E-11						
8.93504E-10	7.75666E-11	6.23151E-10	4.35625E-10	1.09701E-09	1.25146E-09	
5.09903E-10	7.03790E-10	4.83955E-10	9.72531E-10	2.30037E-10	1.70825E-10	
2.96334E-11						
9.30291E-10	7.90750E-11	7.10302E-10	4.38904E-10	1.09432E-09	1.24139E-09	
4.86280E-10	6.84709E-10	4.39984E-10	9.88107E-10	1.98687E-10	1.43730E-10	

TABLE 3-4 (Continued)

```
3.02720E-11
9.50074E-10 8.06468E-11 7.64078E-10 4.47592E-10 1.11155E-09 1.26325E-09
4.83614E-10 6.87861E-10 4.23868E-10 9.96754E-10 1.78556E-10 1.23572E-10
2.92790E-11
9.66343E-10 8.25472E-11 8.14827E-10 4.60571E-10 1.14233E-09 1.30702E-09
4.9211[illegible]E-10 7.05106E-10 4.20843E-10 1.01003E-09 1.62178E-10 1.04090E-10
2.70114E-11
9.94108E-10 8.74242E-11 9.09909E-10 4.98942E-10 1.24394E-09 1.46080E-09
5.44938E-10 7.82242E-10 4.60721E-10 1.06625E-09 1.51866E-10 7.72846E-11
1.87762E-11
1.00639E-09 9.01978E-11 9.54432E-10 5.22252E-10 1.30887E-09 1.56225E-09
5.85722E-10 8.39723E-10 5.01021E-10 1.11031E-09 1.60380E-10 7.37325E-11
1.32058E-11
1.01899E-09 9.32654E-11 9.97835E-10 5.48520E-10 1.38361E-09 1.68007E-09
6.36103E-10 9.09331E-10 5.55224E-10 1.16725E-09 1.80130E-10 7.95932E-11
7.18580E-12
20U
 0.0          0.0          69.0
21*
   0.0          0.0          3300.0
  T
```

TABLE 3-5

SAMPLE PROBLEM COMPUTER PRINTOUT FOR THE SCAP CODE

```
MSFC SAMPLE PROBLEM - 200 INCH SEPARATION - KAP MERIDIAN RING DATA


PROGRAM SCAP INPUT DATA

NO. OF GROUPS.........................NG     =     13
NO. OF SOURCE GROUPS..................NS     =     13
NO. OF SOURCE POLAR ANGLES............NA     =    -11
NO. OF CROSS SECTION ENERGIES.........NC     =     30
NO. OF ELEMENTS.......................NE     =     10
NO. OF MATERIALS......................NM     =     10
NO. OF ZONES..........................NZ     =     22
NO. OF BOUNDARIES.....................NB     =     21
NO OF POLAR SOURCE RAYS...............NR     =     25
NO OF AZIMUTHAL SOURCE RAYS...........NT     =      1
CROSS SECTIONS(0/1,INPUT/TAPE)........NL     =      1
MOST PROBABLE SOURCE POINT ZONE.......NSZO   =      1
NO. OF SOURCE POINTS IN PROBLEM.......NPT    =      1
BUILDUP TYPE..........................NBT    =      1
TYPE OF CALCULATION(0/1,SING./ALB.)...NTY    =      0


POLAR ANGLE LOWER LIMIT...............TH1    =     0.
POLAR ANGLE UPPER LIMIT...............TH2    =     2.53110E+01
AZIMUTHAL ANGLE LOWER LIMIT...........TT1    =     0.
AZIMUTHAL ANGLE UPPER LIMIT...........TT2    =     1.80000E+02
RADIUS OF MERIDIAN RING...............RM     =     9.14400E+02
ELECTRON PATH LENGTH PER SCATTER......DED    =     6.00000E+00
SOURCE RAY PATH LENGTH................RP     =     1.00000E+04
SOURCE SCALING FACTOR.................SCALE  =     1.00000E+00
EXCLUSION RADIUS ON PRIMARY LEG.......RX     =     3.00000E+02


DATA STORAGE REQUIREMENTS AND LIMITS............   2704   5000

    1S ARRAY      22 ENTRIES READ

    2S ARRAY     132 ENTRIES READ

    3S ARRAY     132 ENTRIES READ

    4S ARRAY      21 ENTRIES READ
```

TABLE 3-5 (Continued)

```
    7* ARRAY       21 ENTRIES READ
    8* ARRAY       21 ENTRIES READ
    9* ARRAY       21 ENTRIES READ
   10* ARRAY       21 ENTRIES READ
NON-STANDARD INPUT FORMAT USED
   11* ARRAY       21 ENTRIES READ
NON-STANDARD INPUT FORMAT USED
   12U ARRAY       30 ENTRIES READ
NON-STANDARD INPUT FORMAT USED
   13U ARRAY       10 ENTRIES READ
   14U ARRAY      100 ENTRIES READ
NON-STANDARD INPUT FORMAT USED
   15S ARRAY       22 ENTRIES READ
NON-STANDARD INPUT FORMAT USED
   16U ARRAY       13 ENTRIES READ
NON-STANDARD INPUT FORMAT USED
   17U ARRAY       14 ENTRIES READ
NON-STANDARD INPUT FORMAT USED
   18U ARRAY       11 ENTRIES READ
NON-STANDARD INPUT FORMAT USED
   19U ARRAY      143 ENTRIES READ
   20U ARRAY        3 ENTRIES READ
   21* ARRAY        3 ENTRIES READ
```

TABLE 3-5 (Continued)

T

ELEMENT NAME	ID NUMBER	ATOMIC NO.	ATOMIC WT.
HYDROGEN	27	1.0000	1.0080
CARBON	27	6.0000	12.0111
NITROGEN	27	7.0000	14.0067
OXYGEN	27	8.0000	15.9994
ALUMINUM	27	13.0000	26.9815
SULFUR	27	16.0000	32.0640
CHROMIUM	27	24.0000	51.9960
MANGANESE	27	25.0000	54.9380
IRON	27	26,0000	55,8470
LEAD	35	82.0000	203.9730

NO. OF BOUNDARY SURFACES AND MATERIAL BY ZONE

1	4	9
2	3	1
3	3	2
4	2	3
5	3	3
6	4	2
7	4	1
8	4	9
9	3	4
10	3	4
11	3	4
12	4	2
13	4	1
14	4	9
15	3	4
16	2	4
17	3	2
18	3	1
19	4	9
20	-2	9
21	-1	9
22	-2	9

BOUNDARY SURFACE NO.'S BY ZONE

BND.	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7	ZONE 8
1	-1	2	3	4	-5	-5	-5	-5
2	21	5	5	5	15	16	17	21
3	5	-3	-4	0	6	8	8	8
4	-2	0	0	0	0	-15	-16	-17

TABLE 3-5 (Continued)

5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0

BND.	ZONE 9	ZONE 10	ZONE 11	ZONE 12	ZONE 13	ZONE 14	ZONE 15	ZONE 16
1	-6	-7	-8	-8	-8	-8	-9	-10
2	15	15	18	19	20	21	18	11
3	7	8	9	10	10	10	10	0
4	0	0	0	-18	-19	-20	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0

BND.	ZONE 17	ZONE 18	ZONE 19	ZONE 20	ZONE 21	ZONE 22
1	-10	-10	-10	-14	-21	21
2	12	13	21	21	0	1
3	-11	-12	14	0	0	0
4	0	0	-13	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0

ZONE NO.#S AT BOUNDARY CROSSINGS

BND.	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7	ZONE 8
1	22	1	2	3	4	3	2	1
2	21	7	6	5	6	7	8	21
3	8	3	4	9	9	11	13	14
4	2	0	0	0	0	5	6	7
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0

BND.	ZONE 9	ZONE 10	ZONE 11	ZONE 12	ZONE 13	ZONE 14	ZONE 15	ZONE 16
1	5	9	10	6	7	8	11	15
2	6	6	12	13	14	21	12	17
3	10	11	15	17	18	19	16	0
4	0	0	0	11	12	13	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0

BND.	ZONE 17	ZONE 18	ZONE 19	ZONE 20	ZONE 21	ZONE 22
1	12	13	14	19	1	21
2	18	19	21	21	0	1
3	16	17.	20	0	0	0
4	0	0	18	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0

CROSS SECTION ENERGIES,ELECTRONS/ATOM,ELECTRONS/CC

1	1.00000F+01	1.00000E+00	1.79933F-02
2	8.00000E+00	6.00000E+00	7.83761E-01
3	7.00000E+00	7.00000E+00	4.18401E-02
4	6.00000E+00	8.00000E+00	5.25990E-04
5	5.00000E+00	1.30000E+01	9.07543E-02
6	4.00000E+00	1.60000E+01	2.74903E+00
7	3.00000E+00	2.40000E+01	2.12587E-04
8	2.50000E+00	2.50000E+01	1.80244E-01
9	2.00000E+00	2.60000E+01	0
10	1.50000E+00	8.20000E+01	2.09003E-02
11	1.00000E+00		
12	9.00000E-01		
13	8.00000E-01		
14	7.00000E-01		
15	6.00000E-01		
16	5.00000E-01		
17	4.00000E-01		
18	3.50000E-01		
19	3.00000E-01		
20	2.50000E-01		
21	2.00000E-01		
22	1.50000E-01		
23	1.00000E-01		
24	8.00000E-02		
25	7.00000E-02		
26	6.00000E-02		
27	5.00000E-02		
28	4.00000E-02		
29	3.00000E-02		
30	2.00000E-02		

COMPOSITIONS BY ELEMENT AND MATERIAL

ELEM.	MAT.. 1	MAT.. 2	MAT.. 3	MAT.. 4	MAT.. 5	MAT.. 6	MAT.. 7	MAT.. 8
1	2.41000E-03	0.	7.00000E-02	8.80000E-04	1.01000E-02	0.	1.10000E-05	3.87000E-02
2	5.50000E-02	0.	0.	0.	4.84000E-02	0.	0.	3.64200F-01
3	0.	0.	0.	0.	3.23000E-02	0.	2.80000E-04	2.83000E-02
4	0.	0.	0.	0.	1.42500E-01	0.	4.04000E-04	1.29400E-01
5	0.	2.70000E+00	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	5.82000E-02	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.
ELEM. 8 THRU ELEM. 9 SAME AS ABOVE								
10	0.	0.	0.	0.	0.	1.13500E+01	0.	0.

ELEM. MAT.. 9 MAT.. 10

TABLE 3-5 (Continued)

```
 1  0.          0.
    ELEM.     2 THRU  ELEM.     4 SAME AS ABOVE
 5  0.          7.20000E-02
 6  0.          0.
    ELEM.     7 THRU  ELEM.    10 SAME AS ABOVE
```

CROSS SECTIONS(CM**-1) BY MATERIAL AND GROUP
(LAST COLUMN IS TOTAL COMPTON PER ELECTRON)

GROUP	MAT. 1	MAT. 2	MAT. 3	MAT. 4	MAT. 5	MAT. 6	MAT. 7	MAT. 8
1	2.32326E-04	2.21262E-02	1.37236E-04	1.72525E-06	1.74183E-03	4.22278E-01	3.50566E-06	2.40884E-03
2	1.92476E-04	1.84485E-02	1.09621E-04	1.37809E-06	1.44897E-03	3.60659E-01	2.93442E-06	2.00188E-03
3	1.67869E-04	1.62563E-02	9.30364E-05	1.16960E-06	1.27530E-03	3.30500E-01	2.57430E-06	1.74897E-03
4	1.43349E-04	1.40474E-02	7.69858E-05	9.67822E-07	1.10060E-03	2.98806E-01	2.21320E-06	1.49654E-03
5	1.16260E-04	1.15153E-02	5.94130E-05	7.46906E-07	8.93455E-04	2.61761E-01	1.79340E-06	1.21194E-03
6	8.58440E-05	8.56108E-03	4.13799E-05	5.20204E-07	6.65366E-04	2.15799E-01	1.33119E-06	8.96872E-04
7	5.15600E-05	5.16679E-03	2.31794E-05	2.91399E-07	3.97958E-04	1.64607E-01	7.93716E-07	5.35530E-04
8	3.18322E-05	3.22284E-03	1.40166E-05	1.76209E-07	2.47227E-04	1.41727E-01	4.91503E-07	3.31433E-04
9	1.76412E-05	1.80868E-03	7.57306E-06	9.52042E-08	1.38066E-04	1.18007E-01	2.73393E-07	1.83809E-04
10	4.42229E-06	4.52170E-04	1.84097E-06	2.31436E-08	3.58786E-05	1.17270E-01	6.86600E-08	4.61304E-05
11	0.	0.	0.	0.	2.67925E-06	2.07854E-01	0.	0.
12	0.	4.22025E-05	0.	0.	3.45573E-06	2.58012E-01	0.	0.
13	0.	8.44050E-05	0.	0.	4.59301E-06	3.28543E-01	0.	0.
14	0.	1.20413E-04	0.	0.	6.47444E-06	4.41241E-01	0.	0.
15	0.	1.81471E-04	0.	0.	9.62345E-06	6.20208E-01	0.	0.
16	0.	3.07475E-04	0.	0.	1.56381E-05	9.48751E-01	0.	0.
17	0.	6.14951E-04	0.	0.	3.10575E-05	1.62260E+00	0.	0.
18	0.	9.27095E-04	0.	0.	5.32377E-05	2.26717E+00	2.22810E-08	5.73718E-06
19	0.	1.48915E-03	0.	0.	8.81443E-05	3.33571E+00	4.45620E-08	1.14744E-05
20	2.52430E-06	2.61635E-03	0.	0.	1.56161E-04	5.39622E+00	8.01022E-08	3.73040E-05
21	5.04861E-06	5.21503E-03	0.	0.	3.09092E-04	9.72218E+00	1.64195E-07	7.55401E-05
22	1.28560E-05	1.26608E-02	0.	0.	7.52645E-04	2.07854E+01	4.15574E-07	1.91834E-04
23	4.74514E-05	4.60007E-02	0.	0.	2.68734E-03	6.03446E+01	1.54002E-06	7.08995E-04
24	9.84893E-05	9.40513E-02	0.	0.	5.51779E-03	2.27298E+01	3.23344E-06	1.47925E-03
25	1.55882E-04	1.44246E-01	0.	0.	8.43334E-03	3.29615E+01	5.03356E-06	2.32047E-03
26	2.64845E-04	2.36334E-01	0.	0.	1.37637E-02	5.06224E+01	8.39009E-06	3.90245E-03
27	4.88308E-04	4.25040E-01	0.	0.	2.46664E-02	8.31414E+01	1.53419E-05	7.15205E-03
28	1.02076E-03	8.74195E-01	0.	0.	5.04535E-02	1.52202E+02	3.21823E-05	1.49813E-02
29	2.70363E-03	2.23070E+00	0.	0.	1.26996E-01	3.28878E+02	8.41417E-05	3.94142E-02
30	1.05386E-02	8.25964E+00	0.	0.	4.61250E-01	9.58808E+02	3.23268E-04	1.52151E-01

GROUP	MAT. 9	MAT. 10	MAT. 11
1	0.	5.90031E-04	5.09911E-02
2	0.	4.91961E-04	5.98872E-02
3	0.	4.33500E-04	6.58083E-02
4	0.	3.74598E-04	7.32335E-02

TABLE 3-5 (Continued)

5	0.	3.07074E-04	8.28697E-02
6	0.	2.28296E-04	9.59790E-02
7	0.	1.37781E-04	1.15097E-01
8	0.	8.59425E-05	1.28532E-01
9	0.	4.82314E-05	1.46367E-01
10	0.	1.20579E-05	1.71585E-01
11	0.	0.	2.11219E-01
12	0.	1.12540E-06	2.22268E-01
13	0.	2.25080E-06	2.34972E-01
14	0.	3.21102E-06	2.49815E-01
15	0.	4.83922E-06	2.67511E-01
16	0.	8.19935E-06	2.89181E-01
17	0.	1.63987E-05	3.16696E-01
18	0.	2.47225E-05	3.33611E-01
19	0.	3.97106E-05	3.53469E-01
20	0.	6.97694E-05	3.77261E-01
21	0.	1.39067E-04	4.06504E-01
22	0.	3.37620E-04	4.43628E-01
23	0.	1.22669E-03	4.92774E-01
24	0.	2.50804E-03	5.17312E-01
25	0.	3.84657E-03	5.30951E-01
26	0.	6.30224E-03	5.45648E-01
27	0.	1.13344E-02	5.61536E-01
28	0.	2.33119E-02	5.78768E-01
29	0.	5.94855E-02	5.97525E-01
30	0.	2.20257E-01	6.18019E-01

SURFACE EQUATION NO. AND COEFF. (A,X,B,Y,C,Z,D)

1	6	0	0	0	0	0	0	-1.00000E+03
2	8	1.00000E+00	0	1.00000E+00	0	1.00000E+00	8.44540E+02	2.61540E+02
3	8	1.00000E+00	0	1.00000E+00	0	1.00000E+00	8.44540E+02	2.56460E+02
4	8	1.00000E+00	0	1.00000E+00	0	1.00000E+00	8.44540E+02	2.56040E+02
5	6	0	0	0	0	0	0	7.76970E+02
6	6	0	0	0	0	0	0	8.98500E+02
7	6	0	0	0	0	0	0	1.28850E+03
8	6	0	0	0	0	0	0	1.65584E+03
9	6	0	0	0	0	0	0	2.18850E+03
10	6	0	0	0	0	0	0	2.40984E+03
11	8	1.00000E+00	0	1.00000E+00	0	2.10900E+00	2.40984E+03	4.87260E+02
12	8	1.00000E+00	0	1.00000E+00	0	2.10800E+00	2.40984E+03	4.87680E+02
13	8	1.00000E+00	0	1.00000E+00	0	2.08800E+00	2.40984E+03	4.92760E+02
14	6	0	0	0	0	0	0	2.75600E+03
15	2	1.00000E+00	0	1.00000E+00	0	-7.17972E-02	-1.61900E+02	0
16	2	1.00000E+00	0	1.00000E+00	0	-7.17972E-02	-1.63500E+02	0
17	2	1.00000E+00	0	1.00000E+00	0	-7.17972E-02	-1.83100E+02	0
18	9	0	0	0	0	0	0	4.87260E+02

TABLE 3-5 (Continued)

19	9	0	0	0	0	0	0	4.87680E+02
20	9	0	0	0	0	0	0	4.92760E+02
21	9	0	0	0	0	0	0	1.00000E+03

SOURCE ENERGIES,FLUX ENERGIES,AND ALBEDO DATA

1	8.50000E+00	1.00000E+01	0	0	0
2	7.25000E+00	7.50000E+00	0	0	0
3	6.50000E+00	7.00000E+00	0	0	0
4	5.50000E+00	6.00000E+00	0	0	0
5	4.50000E+00	5.00000E+00	0	0	0
6	3.50000E+00	4.00000E+00	0	0	0
7	2.80000E+00	3.00000E+00	0	0	0
8	2.50000E+00	2.60000E+00	0	0	0
9	2.20000E+00	2.40000E+00	0	0	0
10	1.50000E+00	1.80000E+00	0	0	0
11	1.00000E+00	1.35000E+00	0	0	0
12	7.00000E-01	9.00000E-01	0	0	0
13	3.00000E-01	4.00000E-01	0	0	0
14		2.00000E-02			

SOURCE POLAR ANGLES

1	0
2	1.02631E+01
3	1.25781E+01
4	1.45337E+01
5	1.54206E+01
6	1.78242E+01
7	1.92655E+01
8	2.06097E+01
9	2.30739E+01
10	2.42168E+01
11	2.53111E+01

SOURCE DATA BY ANGLE AND GROUP FOR POINT 1

SOURCE POINT COORDINATES

1	0.
2	0.
3	0.69000E+02

ANGLE	GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5	GROUP 6	GROUP 7	GROUP 8
1	5.08435E-10	5.99838E-11	3.51039E-10	3.79753E-10	9.66830E-10	1.18632E-09	5.10893E-10	7.34021E-10
2	7.68543E-10	7.33622E-11	4.49073E-10	4.28143E-10	1.08863E-09	1.25515E-09	5.32762E-10	7.21633E-10

TABLE 3-5 (Continued)

3	8.35503E-10	7.60160E-11	5.23716E-10	4.35960E-10	1.10666E-09	1.26950E-09	5.32227E-10	7.20824E-10
4	8.76581E-10	7.70827E-11	5.91573E-10	4.35708E-10	1.10081E-09	1.25875E-09	5.18619E-10	7.10921E-10
5	8.93504E-10	7.75666E-11	6.23151E-10	4.35625E-10	1.09701E-09	1.25146E-09	5.09903E-10	7.03790E-10
6	9.30291E-10	7.90750E-11	7.10302E-10	4.38904E-10	1.09432E-09	1.24139E-09	4.86280E-10	6.84709E-10
7	9.50074E-10	8.06468E-11	7.64078E-10	4.47592E-10	1.11155E-09	1.26325E-09	4.83614E-10	6.87861E-10
8	9.66343E-10	8.25472E-11	8.14827E-10	4.60571E-10	1.14233E-09	1.30702E-09	4.92114E-10	7.05106E-10
9	9.94108E-10	8.74242E-11	9.09909E-10	4.98942E-10	1.24394E-09	1.46080E-09	5.44938E-10	7.82242E-10
10	1.00639E-09	9.01978E-11	9.54432E-10	5.22252E-10	1.30887E-09	1.56225E-09	5.85722E-10	8.39723E-10
11	1.01899E-09	9.32654E-11	9.97835E-10	5.48520E-10	1.38361E-09	1.68007E-09	6.36103E-10	9.09331E-10

ANGLE	GROUP 9	GROUP 10	GROUP 11	GROUP 12	GROUP 13
1	5.42922E-10	5.62789E-10	2.56095E-10	2.09401E-10	1.41040E-11
2	5.29995E-10	8.16192E-10	2.48061E-10	1.90839E-10	2.12592E-11
3	5.19774E-10	9.07994E-10	2.45092E-10	1.84491E-10	2.57884E-11
4	4.97909E-10	9.58278E-10	2.36930E-10	1.76545E-10	2.86881E-11
5	4.83955E-10	9.72531E-10	2.30037E-10	1.70825E-10	2.96334E-11
6	4.39984E-10	9.88107E-10	1.98687E-10	1.43730E-10	3.02720E-11
7	4.23868E-10	9.96754E-10	1.78556E-10	1.23572E-10	2.92790E-11
8	4.20843E-10	1.01003E-09	1.62178E-10	1.04090E-10	2.70114E-11
9	4.60721E-10	1.06625E-09	1.51866E-10	7.72846E-11	1.87762E-11
10	5.01021E-10	1.11031E-09	1.60380E-10	7.37325E-11	1.32058E-11
11	5.55224E-10	1.16725E-09	1.80130E-10	7.95932E-11	7.18580E-12

DETECTOR POINT COORDINATES

1	0
2	0
3	3.30000E+03

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TABLE 3-5 (Continued)

MSFC SAMPLE PROBLEM - 200 INCH SEPARATION - KAP MERIDIAN RING DATA

SOURCE POINT NO. = 1

SOURCE POLAR ANGLE LIMITS

1	0
2	1.01244E+00
3	2.02488E+00
4	3.03732E+00
5	4.04976E+00
6	5.06220E+00
7	6.07464E+00
8	7.08708E+00
9	8.09952E+00
10	9.11196E+00
11	1.01244E+01
12	1.11368E+01
13	1.21493E+01
14	1.31617E+01
15	1.41742E+01
16	1.51866E+01
17	1.61990E+01
18	1.72115E+01
19	1.82239E+01
20	1.92364E+01
21	2.02488E+01
22	2.12612E+01
23	2.22737E+01
24	2.32861E+01
25	2.42986E+01
26	2.53110E+01

SOURCE DATA (MEV/SEC) - TOTAL IN SOLID ANGLE
LAST LINE IN EACH COLUMN IS TOTAL

ANGLE	GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5	GROUP 6	GROUP 7	GROUP 8
1	4.30998E-07	4.99168E-08	2.93187E-07	3.14066E-07	7.99519E-07	9.76688E-07	4.20176E-07	6.01356E-07
2	1.34904E-06	1.52624E-07	9.00644F-07	9.52552E-07	2.42462E-06	2.94463E-06	1.26518E-06	1.80120F-06
3	2.35082E-06	2.59613E-07	1.53953E-06	1.60640E-06	4.08836E-06	4.93391E-06	2.11685E-06	2.99648E-06
4	3.43595E-06	3.70845E-07	2.20964E-06	2.27538E-06	5.79021E-06	6.94391E-06	2.97492E-06	4.18682E-06
5	4.60402E-06	4.86283E-07	2.91072E-06	2.95929E-06	7.52959E-06	8.97398E-06	3.83913E-06	5.37185E-06
6	5.85457E-06	6.05885E-07	3.64252E-06	3.65788E-06	9.30591E-06	1.10234E-05	4.70919E-06	6.55121E-06
7	7.18707E-06	7.29606E-07	4.40475E-06	4.37092E-06	1.11186E-05	1.30916E-05	5.58483E-06	7.72453E-06

TABLE 3-5 (Continued)

8	8.60095E-06	8.57401E-07	5.19713E-06	5.09815E-06	1.29669E-05	1.51779E-05	6.46576E-06	8.89145E-06
9	1.00956E-05	9.89220E-07	6.01933E-06	5.83931E-06	1.48502E-05	1.72814E-05	7.35168E-06	1.00516E-05
10	1.16703E-05	1.12501E-06	6.87103E-06	6.59413E-06	1.67679E-05	1.94017E-05	8.24230E-06	1.12047E-05
11	1.33566E-05	1.26417E-06	7.90501E-06	7.35512E-06	1.86961E-05	2.15374E-05	9.12169E-06	1.23558E-05
12	1.51667E-05	1.40513E-06	9.25884E-06	8.11185E-06	2.06045E-05	2.36816E-05	9.97486E-06	1.35101E-05
13	1.70199E-05	1.54613E-06	1.07174E-05	8.86060E-06	2.24835E-05	2.57887E-05	1.07989E-05	1.46420E-05
14	1.88418E-05	1.68090E-06	1.23259E-05	9.55980E-06	2.42010E-05	2.77109E-05	1.15017E-05	1.55860E-05
15	2.06902E-05	1.81547E-06	1.40470E-05	1.02501E-05	2.58797E-05	2.95786E-05	1.21599E-05	1.66907E-05
16	2.25442E-05	1.95229E-06	1.59013E-05	1.09491E-05	2.75384E-05	3.13941E-05	1.27286E-05	1.76118E-05
17	2.43810E-05	2.09198E-06	1.78797E-05	1.16726E-05	2.92330E-05	3.32452E-05	1.32540E-05	1.84966E-05
18	2.62381E-05	2.23342E-06	1.99660E-05	1.24069E-05	3.09490E-05	3.51262E-05	1.37803E-05	1.93869E-05
19	2.81068E-05	2.38701E-06	2.21866E-05	1.32483E-05	3.29481E-05	3.74200E-05	1.44447E-05	2.0470[illegible]-05
20	2.99773E-05	2.55048E-06	2.45300E-05	1.41827E-05	3.52049E-05	4.01083E-05	1.52617E-05	2.17655E-05
21	3.18465E-05	2.72679E-06	2.69967E-05	1.52417E-05	3.78231E-05	4.33654E-05	1.63261E-05	2.33885E-05
22	3.37269E-05	2.92196E-06	2.95946E-05	1.64831E-05	4.09854E-05	4.74911E-05	1.78007E-05	2.55281E-05
23	3.56179E-05	3.12252E-06	3.23031E-05	1.77773E-05	4.42986E-05	5.18759E-05	1.93754E-05	2.78059E-05
24	3.75215E-05	3.33985E-06	3.51294E-05	1.92374E-05	4.81223E-05	5.71026E-05	2.13706E-05	3.06519E-05
25	3.94606E-05	3.57743E-06	3.80837E-05	2.08914E-05	5.25438E-05	6.33094E-05	2.38644E-05	3.41592E-05
26	4.50075E-04	4.02419E-05	3.50814E-04	2.29896E-04	5.77153E-04	6.69485E-04	2.64734E-04	3.71531E-04

ANGLE	GROUP 9	GROUP 10	GROUP 11	GROUP 12	GROUP 13
1	4.44593E-07	4.75217E-07	2.09609E-07	1.70746E-07	1.19527E-08
2	1.33085E-06	1.48024E-06	6.27027E-07	5.08175E-07	3.73998E-08
3	2.21251E-06	2.56678E-06	1.04165E-06	8.39440E-07	6.51500E-08
4	3.08929E-06	3.73444E-06	1.45335E-06	1.16444E-06	9.51932E-08
5	3.96094E-06	4.98279E-06	1.86200E-06	1.48309E-06	1.27518E-07
6	4.82718E-06	6.31132E-06	2.26748E-06	1.79528E-06	1.62111E-07
7	5.68775E-06	7.71951E-06	2.66966E-06	2.10093E-06	1.98958E-07
8	6.54239E-06	9.20676E-06	3.06843E-06	2.39996E-06	2.38043E-07
9	7.39084E-06	1.07724E-05	3.46366E-06	2.69228E-06	2.79350E-07
10	8.23284E-06	1.24158E-05	3.85524E-06	2.97783E-06	3.22858E-07
11	9.04491E-06	1.42442E-05	4.23907E-06	3.24873E-06	3.76876E-07
12	9.80979E-06	1.63401E-05	4.61267E-06	3.50091E-06	4.49223E-07
13	1.05363E-05	1.84922E-05	4.97115E-06	3.74132E-06	5.26270E-07
14	1.11227E-05	2.05465E-05	5.27232E-06	3.94556E-06	6.01595E-07
15	1.16478E-05	2.25904E-05	5.53962E-06	4.12560E-06	6.78203E-07
16	1.20085E-05	2.44609E-05	5.66968E-06	4.19624E-06	7.45503E-07
17	1.22516E-05	2.61804E-05	5.66117E-06	4.14372E-06	8.00130E-07
18	1.24886E-05	2.78974E-05	5.63834E-06	4.07644E-06	8.52276E-07
19	1.28068E-05	2.96191E-05	5.53312E-06	3.89186E-06	8.83372E-07
20	1.32570E-05	3.14072E-05	5.40755E-06	3.64281E-06	8.91704E-07
21	1.39625E-05	3.33696E-05	5.32713E-06	3.36189E-06	8.63736E-07
22	1.51384E-05	3.56964E-05	5.40827E-06	3.10376E-06	7.80344E-07
23	1.64076E-05	3.81052E-05	5.50850E-06	2.87894E-06	7.01167E-07
24	1.82042E-05	4.09760E-05	5.88979E-06	2.81022E-06	5.64047E-07
25	2.06418E-05	4.44381E-05	6.65664E-06	2.99418E-06	3.74158E-07
26	2.43048E-04	4.84029E-04	1.01853E-04	6.97944E-05	1.16271E-05

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TABLE 3-5 (Continued)

MSFC SAMPLE PROBLEM - 200 INCH SEPARATION - KAP MERIDIAN RING DATA

SOURCE POINT NO. = 1

RESULTS - SINGLE SCATTER OR REFLECTED W/O BUILDUP(MEV/CM**2-SEC)

(LAST LINE IN EACH COLUMN IS TOTAL)

GROUP	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7	ZONE 8
1	0.	5.95488E-15	2.14950E-14	5.29930E-13	2.79989E-13	0.	0.	0.
2	0.	4.00115E-15	1.44532E-14	1.70340E-13	2.33754E-13	0.	0.	0.
3	0.	9.36770E-15	3.38680E-14	7.51501E-13	5.53230E-13	0.	0.	0.
4	0.	1.57014E-14	5.68623E-14	1.17344E-12	8.47025E-13	0.	0.	0.
5	0.	3.29451E-14	1.19689E-13	2.25311E-12	1.60504E-12	0.	0.	0.
6	0.	6.76281E-14	2.50691E-13	3.49979E-12	3.24420E-12	5.16488E-14	2.05328E-14	0.
7	0.	4.02998E-14	1.51911E-13	1.64848E-12	1.48659E-12	1.56913E-13	3.91766E-14	0.
8	0.	1.66517E-14	6.08853E-14	9.74268E-13	9.16143E-13	5.82843E-14	3.84879E-14	0.
9	0.	6.28376E-14	2.36120E-13	2.56551E-12	2.49211E-12	5.37047E-13	1.25003E-13	0.
10	0.	2.32622E-14	8.86313E-14	8.47957E-13	8.97130E-13	2.75400E-13	7.98273E-14	0.
11	0.	2.46443E-14	9.31461E-14	7.28036E-13	8.12346E-13	1.59373E-13	5.17680E-14	0.
12	0.	5.12985E-15	1.93054E-14	1.55477E-13	1.62424E-13	3.25418E-14	1.18895E-14	0.
13	0.	1.65846E-16	6.10392E-16	4.21951E-15	4.29952E-15	6.22382E-16	5.43898E-16	0.
14	0.	3.08590E-13	1.14767E-12	1.53021E-11	1.35343E-11	1.27183E-12	3.67229E-13	0.

GROUP	ZONE 9	ZONE 10	ZONE 11	ZONE 12	ZONE 13	ZONE 14	ZONE 15	ZONE 16
1	1.37577E-14	1.18229E-14	1.65724E-14	0.	0.	0.	5.79515E-15	1.48427E-14
2	5.61740E-15	5.80653E-15	1.09452E-14	0.	0.	0.	5.64782E-15	4.79028E-16
3	2.30635E-14	1.97099E-14	2.20308E-14	0.	0.	0.	9.94089E-15	1.44575E-14
4	3.08888E-14	2.90041E-14	4.27317E-14	0.	0.	0.	1.56527E-14	3.17384E-14
5	7.17056E-14	5.88779E-14	8.68163E-14	0.	0.	0.	3.94702E-14	3.96964E-14
6	1.32478E-13	1.21536E-13	1.56135E-13	0.	0.	0.	6.14225E-14	9.44485E-14
7	6.08499E-14	6.19709E-14	1.00497E-13	0.	0.	0.	3.59063E-14	4.65190E-14
8	4.04240E-14	4.24666E-14	5.77530E-14	0.	0.	0.	2.37039E-14	4.50007E-14
9	1.14106E-13	1.26941E-13	2.03080E-13	1.90986E-13	3.69683E-14	0.	8.69217E-14	1.05954E-13
10	4.78253E-14	5.68641E-14	1.08924E-13	3.48997E-13	8.23680E-14	0.	5.29507E-14	7.95340E-14
11	3.40219E-14	3.65071E-14	5.45969E-14	2.38531E-13	5.55706E-14	0.	3.01336E-14	3.67[illegible]48E-14
12	7.78142E-15	9.01137E-15	1.57019E-14	3.34872E-14	6.60986E-15	0.	7.35593E-15	1.04669E-14
13	1.66959E-16	1.66472E-16	2.28481E-16	5.92793E-16	9.84659E-17	0.	9.11568E-17	1.08686E-16
14	5.82686E-13	5.80684E-13	8.76012E-13	8.12594E-13	1.81615E-13	0.	3.74993E-13	5.21001E-13

GROUP	ZONE 17	ZONE 18	ZONE 19	ZONE 20	ZONE 21	ZONE 22
1	1.21888E-14	3.92027E-15	0.	0.	0.	0.
2	2.48067E-14	7.94113E-15	0.	0.	0.	0.
3	9.75714E-15	3.13490E-15	0.	0.	0.	0.
4	4.42103E-16	1.41226E-14	0.	0.	0.	0.

TABLE 3-5 (Continued)

5	1.07247E-13	3.42863E-14	0.	0.	0.	0.
6	1.29385E-13	4.12579E-14	0.	0.	0.	0.
7	1.04965E-13	3.34117E-14	0.	0.	0.	0.
8	7.09491E-14	2.24990E-14	0.	0.	0.	0.
9	2.49504E-13	7.90321E-14	0.	0.	0.	0.
10	2.64414E-13	8.34332E-14	0.	0.	0.	0.
11	2.10871E-13	6.70269E-14	0.	0.	0.	0.
12	6.14496E-14	1.96124E-14	0.	0.	0.	0.
13	3.76104E-16	1.21561E-16	0.	0.	0.	0.
14	1.29012E-12	4.09800E-13	0.	0.	0.	0.

TABLE 3-5 (Continued)

MSFC SAMPLE PROBLEM - 200 INCH SEPARATION - KAP MERIDIAN RING DATA

SOURCE POINT NO. = 1

RESULTS - SINGLE SCATTER OR REFLECTED W/O BUILDUP (MEV/CM**2-SEC)

(LAST LINE IN EACH COLUMN IS TOTAL)

GROUP	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5	ZONE 6	ZONE 7	ZONE 8
1	0.	8.02119E-15	2.88200E-14	6.60414E-13	3.07182E-13	0.	0.	0.
2	0.	5.55828E-15	1.99769E-14	2.16805E-13	2.59120E-13	0.	0.	0.
3	0.	1.35705E-14	4.87902E-14	9.85789E-13	6.23350E-13	0.	0.	0.
4	0.	2.41595E-14	8.69327E-14	1.62154E-12	9.77778E-13	0.	0.	0.
5	0.	5.56568E-14	2.00601E-13	3.37625E-12	1.92178E-12	0.	0.	0.
6	0.	1.27770E-13	4.67401E-13	5.84320E-12	4.11202E-12	5.84915E-14	2.71660E-14	0.
7	0.	8.45790E-14	3.13084E-13	3.05048E-12	1.99296E-12	1.70459E-13	5.28340E-14	0.
8	0.	3.89461E-14	1.40538E-13	1.90161E-12	1.26943E-12	6.66673E-14	5.57451E-14	0.
9	0.	1.58558E-13	5.83035E-13	5.55499E-12	3.64552E-12	6.39240E-13	1.79223E-13	0.
10	0.	7.23472E-14	2.67119E-13	2.33161E-12	1.45984E-12	3.42601E-13	1.26977E-13	0.
11	0.	9.34301E-14	3.41386E-13	2.27190E-12	1.46288E-12	2.11421E-13	1.04712E-13	0.
12	0.	3.21482E-14	1.15202E-13	7.62360E-13	3.57755E-13	4.63384E-14	3.29475E-14	0.
13	0.	4.32263E-15	1.48491E-14	7.43221E-14	2.08020E-14	1.32354E-15	4.93577E-15	0.
14	0.	7.19067E-13	2.62774E-12	2.86513E-11	1.84104E-11	1.54554E-12	5.84440E-13	0.

GROUP	ZONE 9	ZONE 10	ZONE 11	ZONE 12	ZONE 13	ZONE 14	ZONE 15	ZONE 16
1	1.42590E-[illegible]	[illegible]2E-14	1.70050E-14	0.	0.	0.	5.91886E-15	1.51148E-14
2	5.83946E-[illegible]	[illegible].04[illegible]7E-15	1.12539E-14	0.	0.	0.	5.77739E-15	4.88121E-16
3	2.40856E-14	[illegible].04599E-14	2.27121E-14	0.	0.	0.	1.01897E-14	1.47534E-14
4	3.24918E-14	3.02908E-14	4.42414E-14	0.	0.	0.	1.60948E-14	3.24701E-14
5	7.63646E-14	6.21032E-14	9.05982E-14	0.	0.	0.	4.08298E-14	4.07706E-14
6	1.43936E-13	1.30342E-13	1.64990E-13	0.	0.	0.	6.41375E-14	9.76359E-14
7	6.73839E-14	6.75950E-14	1.07610E-13	0.	0.	0.	3.78737E-14	4.84845E-14
8	4.52865E-14	4.67913E-14	6.24264E-14	0.	0.	0.	2.51860E-14	4.71750E-14
9	1.30421E-13	1.42492E-13	2.22938E-13	2.24968E-13	4.64418E-14	0.	9.36617E-14	1.13619E-13
10	5.68997E-14	6.60869E-14	1.23375E-13	4.24906E-13	1.07962E-13	0.	5.87231E-14	8.69841E-14
11	4.22491E-14	4.40946E-14	6.38771E-14	3.04448E-13	7.77025E-14	0.	3.43876E-14	4.16332E-14
12	1.03017E-14	1.14819E-14	1.91542E-14	4.63969E-14	1.04261E-14	0.	8.67968E-15	1.21099E-14
13	3.04462E-16	2.79631E-16	3.50376E-16	1.16658E-15	2.49499E-16	0.	1.29454E-16	1.47845E-16
14	6.49823E-13	6.40219E-13	9.50531E-13	1.00189E-12	2.42782E-13	0.	4.01589E-13	5.51386E-13

GROUP	ZONE 17	ZONE 18	ZONE 19	ZONE 20	ZONE 21	ZONE 22
1	1.23282E-14	3.94334E-15	0.	0.	0.	0.
2	2.51000E-14	7.98287E-15	0.	0.	0.	0.
3	9.87391E-15	3.14975E-15	0.	0.	0.	0.
4	4.47760E-14	1.41820E-14	0.	0.	0.	0.

TABLE 3-5 (Continued)

5	1.08783E-13	3.43938E-14	0.	0.	0.	0.
6	1.31631E-13	4.13529E-14	0.	0.	0.	0.
7	1.07132E-13	3.34761E-14	0.	0.	0.	0.
8	7.26985E-14	2.25440E-14	0.	0.	0.	0.
9	2.57996E-13	7.92654E-14	0.	0.	0.	0.
10	3.00811E-13	8.83914E-14	0.	0.	0.	0.
11	2.64363E-13	7.55724E-14	0.	0.	0.	0.
12	8.40956E-14	2.35288E-14	0.	0.	0.	0.
13	6.03674E-16	1.56450E-16	0.	0.	0.	0.
14	1.42019E-12	4.27939E-13	0.	0.	0.	0.

TABLE 3-5 (Continued)

MSFC SAMPLE PROBLEM - 200 INCH SEPARATION - KAP MERIDIAN RING DATA

SOURCE POINT NO. = 1

RESULTS - SUMMARY

(LAST LINE IN EACH COLUMN IS TOTAL)

	DOSE RATES W/O BUILDUP (RADS(C)/HR)	W/ BUILDUP (RADS(C)/HR)	BY RAY (RADS(C)/HR)	BY COMP. (RADS(C)/HR)	SCATTER VOLUME BY ZONE (CC)	HEAT DEPOSITION BY ZONE (KILOWATTS)	BY COMP. (KILOWATTS)
1	0	0	4.72814E-19	2.69220E-18	0	0	9.60344E-21
2	3.82047E-19	9.33722E-19	1.33402E-18	8.96551E-18	1.08969E+06	3.60303E-21	3.55005E-20
3	1.42410E-18	3.41362E-18	2.02995E-18	5.84801E-17	9.72959E+04	1.45137E-20	1.78907E-19
4	1.82443E-17	3.56190E-17	2.59749E-18	4.01412E-18	2.16174E+07	1.11420E-19	6.00492E-21
5	1.64578E-17	2.28604E-17	3.07511E-18	0	2.75270E+07	6.74872E-20	0
6	1.75692E-18	2.14500E-18	3.48028E-18	0	6.64892E+05	1.29469E-20	0
7	5.08613E-19	8.22631E-19	3.81975E-18	0	9.73639E+06	4.07868E-21	0
8	0	0	4.09678E-18	0	0	0	0
9	7.12946E-19	8.00952E-19	4.31997E-18	0	1.41217E+08	1.99086E-21	0
10	7.20941E-19	8.00054E-19	4.49563E-18	0	2.19250E+08	1.59137E-21	0
11	1.10038E-18	1.20059E-18	4.58484E-18		3.97366E+08	1.63215E-21	
12	1.20630E-18	1.49112E-18	4.87038E-18		8.87395E+05	6.01487E-21	
13	2.69458E-19	3.61408E-19	5.01214E-18		1.08548E+07	1.42460E-21	
14	0	0	4.94417E-18		0	0	
15	4.76828E-19	5.13186E-19	4.84276E-18		1.66483E+08	4.40802E-22	
16	6.57769E-19	6.99341E-19	4.71401E-18		1.66674E+08	3.49738E-22	
17	1.71961E-18	1.91577E-18	4.55802E-18		5.63200E+05	2.02504E-21	
18	5.46478E-19	5.74438E-19	5.41244E-18		6.90212E+06	4.97129E-22	
19	0	0	5.03437E-18		0	0	
20	0	0	4.57041E-19		0	0	
21	0	0	0		0	0	
22	0	0	0		0	0	
23	4.61844E-17	7.41520E-17	0		0	2.30016E-19	
24			0				
25			0				

TOTAL NUMBER OF SCATTER OR ALBEDO POINTS= 209

TOTAL DIRECT DOSE RATE(RADS(C)/HR) = 1.12379E-16 TOTAL DOSE RATE(RADS(C)/HR) = 1.86531E-16

TABLE 3-5 (Continued)

MSFC SAMPLE PROBLEM - 200 INCH SEPARATION - KAP MERIDIAN RING DATA

RESULTS - SUMMATION OVER SOURCE POINTS - (RADS(C)/HR)

FIRST NM ROWS ARE BY COMP. AND LAST THREE ARE SCATTERED,DIRECT,TOTAL

(LAST COLUMN IS SUM)

COMP.	SOURCE 1	SOURCE 2
1	2.69220E-18	2.69220E-18
2	8.96551E-18	8.96551E-18
3	5.84801E-17	5.84801E-17
4	4.01412E-18	4.01412E-18
5	0.	0.
	COMP. 6 THRU COMP. 10 SAME AS ABOVE	
11	7.41520E-17	7.41520E-17
12	1.12379E-16	1.12379E-16
13	1.86531E-16	1.86531E-16

6) A tabulation of the cross section data by energy point and material. If this is a gamma ray problem then these data are the macroscopic absorption cross section (photoelectric plus pair production). If this is a neutron problem the cross sections are macroscopic total (or removal) cross sections,

7) The input surface equation types and their coefficients,

8) The source energy values, flux group energy bounds, and the albedo data by source energy group,

9) The input anisotropic point source data by angle and source group energy for each source point including the source input Cartesian coordinates,

10) The detector point Cartesian coordinates,

11) The calculated results of the point source data (including the source polar angle interval limits) in units of MeV/second or particles/second by angle and group,

12) The single scattered or reflected results by scatter or albedo zone and flux group, with and without buildup for each source point,

13) The summary results of the SCAP calculation of the dose rates with and without buildup by scatter or albedo zone, dose rates by source ray, dose rates by composition, scatter zone volume or albedo scatter zone area, and for gamma ray single scatter calculations the heat deposition by scatter zone and material composition,

14) The total number of scatter or albedo points in the problem for the source point,

15) The total direct (uncollided) dose rate and the total (direct plus scattered) dose rate at the detector point,

16) The final summary results of the summation of dose rates (total direct, and scattered) for all source points in the problem.

The calculated results of the SCAP code are in the units of Rads (carbon)/hour for all gamma ray calculations. This requires that the input source data be in units of MeV/cm^2-second. Neutron data are labeled as Rads (carbon)/hour but the units are defined by the input data DOC specified by the user.

3.6 CODE LOGIC

The general code logic used in the principal SCAP calculations is presented in this section. Extensive use of flexible dimensioning throughout the SCAP code provides for the efficient use of the blank COMMON array to store data and maximize the code capability with a minimum computer memory core size.

Table 3-6 briefly describes the principal function of each subroutine in the SCAP code and is presented to familiarize the user with the overall capability of the SCAP code.

The code logics of the SCAP code involves the initial step of searching DATA SET 1 and 2 in the main routine SCAP and the assignment of core memory storage. The next logical step is the MAIN subroutine which calculates the source leg direction cosines for each source ray of each source point for use in the SCAT subroutine. The MAIN subroutine also calculates the direct (uncollided) results, provides the summary calculation of detector point results, and prints all calculated results.

The SCAT subroutine calculates; the total source of each source ray based on the ray solid angle interval and the meridian ring input data, the scatter-point distribution, the material and inverse square attenuation functions for the source and scatter leg, the scattering probabilities, and the results associated with the scatter point.

Auxiliary subroutines used in the SCAP, MAIN and SCAT routines are defined in Table 3-6.

TABLE 3-6

DESCRIPTION OF SCAP CODE SUBROUTINES

Subroutine Name	Principal Function
SCAP	Reads problem specifications data, allocates core memory storage, reads all input data with subroutine FIDO.
MAIN	Initializes all source point ray calculations,direct (uncollided) calculations, and prints summary output.
SCAT	Calculates the total source of each source ray, the scatter point distribution, the source and scatter leg lenghts, the material and inverse square attenuation on the source and scatter leg, the scattering probability, the detector flux result for the source leg, the scatter volume or area, and the heat deposition (gamma ray only).
CONV	Calculates the gamma ray dose rate conversion factor Rads (carbon)/hour per MeV/cm^2-second based on the scattered energy (or source energy in albedo method).
FIDO	Generalized input data read routine.
RAY	Performs line-of-sight ray trace through complex geometry described by intersecting quadratic surfaces.
GAMX	Calculates the photon absorption and 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.
SIGG	Calculates the differential gamma ray scattering cross section and scattered energy using Klein-Nishina equations for inelastic scattering of a gamma ray with a free electron.

TABLE 3-6 (Continued)

Subroutine Name	Principal Function
BUILD	Calculates the multiple-scatter buildup factor based on the cubic polynominal 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.

3.7 METHOD OF SOLUTION

The numerical technique employed in the SCAP code is an integration of the single- or albedo-scattered flux and dose rate at a detector point in a complex scattering geometry due to a point anisotropic energy-dependent source. This calculation is performed in the SCAP code by calculation of the quantities necessary to define the single-scatter or albedo-scatter technique. The calculations are as follows:

(1) Determination of the direction cosines of source ray emanating from the anisotropic point source.

(2) Integration of energy-dependent source data (i.e., flux as a function of polar angle on a meridian ring) within the solid angle interval to obtain the point source strength in the discrete direction.

(3) Inverse square attenuation of the total energy or particle flux in each solid angle interval into the scattering geometry along "rays" which bisect the solid angle interval (i.e., source leg calculations).

(4) Calculation of material attenuation exponential along the source leg absorption cross sections, σ_a, from a library and Compton scattering cross section, σ_s, computed internally from Klein-Nishina scattering cross section formulae or using input cross sections by material.

(5) Selection of scatter points on the source leg in each material zone or a zone boundary crossing for each ray.

(6) Calculation of a scattering volume or area associated with each scatter point.

(7) Calculation of scattering probabilities and energy degradation using Klein-Nishina formula or albedo formula.

(8) Inverse square attenuation of the scattered energy or particle flux to the detector point (i.e., scatter leg calculations).

(9) Attenuation of the scattered radiation with and without application of an appropriate buildup factor along the ray connecting the scatter point and the detector point.

(10) Calculation of the scattered flux (with and without buildup due to multiple scatter on the scatter leg) and calculation of total response for each ray, each zone and each composition.

(11) Calculation of the direct radiation using meridian ring data at a polar angle which defines the direction from source point to detector point. For the in-line symmetric case, i. e., source and detector both on the reactor and tank axis, this angle is 0°.

In addition to the calculation of the quantities related to the scattered flux at a detector point, the scatter zone volumes, and gamma energy deposition in scatter zones, are calculated and provided as output. The techniques used to obtain each of the above quantities are described in following sections.

3.7.1 Description of Point Sources

The solid angle about the point source in the SCAP code is subdivided according to the order of integration specified by the user. This subdivision is input to the code as the number of intervals and limits in the polar angle integration, and the number of intervals and limits in the azimuthal angle integration. At option the user may input the limits of each interval in the polar angle subdivision. On the basis of the angular limits the solid angle associated with each source ray and the direction cosines of the source ray (α, β, γ) are defined by:

$$\alpha = \sin \bar{\varphi} * \cos \bar{\Theta}$$

$$\beta = \sin \bar{\varphi} * \sin \bar{\Theta}$$

$$\gamma = \cos \bar{\varphi}$$

where $\bar{\varphi}$ = the angle bisecting the polar angle interval,

$\bar{\Theta}$ = the angle bisecting the azimuthal angle interval.

The direction cosines of the source ray and the coordinates of the source point are the starting point of the geometry calculation in the SCAP code.

3.7.2 Energy Dependent Anisotropic Point Sources

Anisotropic point sources are represented in SCAP as a function of polar angle (the angle with respect to the z axis), azimuthal angle, and source energy. These source data are obtained from input meridian ring data (i.e., a spherical detector surface with uniform distribution with respect to azimuth) for the source energy groups. The anisotropy of the source data is in polar angle only. The source data are input as the gamma energy flux (Mev/cm^2-sec) or neutron flux (neutrons/cm^2-sec) by energy group at detector points on a meridian ring. The detector points correspond to polar angles on the meridian ring. The total source strength associated with each source ray emanating from a point source is calculated as the total number of particles or energy emitted in the solid angle defined by the spherical coordinate interval limits ϕ_1, ϕ_2, θ_1, θ_2 determined from SCAP input.

$$q_S(\bar{\phi}, \bar{\theta}, E) = C\, R_m^2 \int_{\theta_1}^{\theta_2} \int_{\cos\phi}^{\cos\phi_2} f(\phi', E)\, d\,\phi'\, d\,\theta'$$

where $\bar{\phi}$ = the polar angle of emission of the source ray, $\bar{\phi}$, bisects the polar angle interval,

$\bar{\theta}$ = the azimuthal angle of emission of the source ray. $\bar{\theta}$ bisects the azimuthal angle interval,

E = the source energy in units of Mev,

C = an input multiplicative factor to normalize the source strength,

R_m = the radius of the meridian ring from the source point

ϕ_1 = the lower limit of the polar angle interval represented by the ray at $\bar{\phi}$. These values are determined from code input data,

ϕ_2 = the upper limit of the polar angle interval represented by the source ray at $\bar{\phi}$. These values are determined from code input data,

$f(\phi', E)$ = the value of the source data (particles or Mev per cm^2) at the polar angle ϕ' for source energy E.

Evaluation of the above equation is carried out by subdividing the polar angle interval defined by ϕ_1 and ϕ_2 into ten subintervals and interpolating the input source data in the polar angle, ϕ', at the midpoint of each subinterval to obtain the source data, $f(\phi', E_g)$. The total source strength associated with the ray is then normalized at option based on the symmetry of the scatter volume about the z axis by applying a factor determined from the limits of the azimuthal integration for the source point and the number of azimuthal integration points used in the numerical integration.

3.7.3 Geometry Calculations

The SCAP code performs calculations to obtain the required geometry-related data for use in the integration of scattered flux to the detector point along each ray. These geometry calculations are similar for both the source leg attenuation (calculation number 3) or the scatter leg attenuation (calculation number 8) described previously.

Geometry ray trace calculations through a complex geometry described as zones defined by intersecting quadratic surfaces are performed in an identical fashion for both source point and scatter point with the source or scatter point at the point of origination of the ray.

The geometry ray trace returns the sequence and line-of-sight lengths through each zone encountered or the ray trace for use in scatter point determination and material attenuation calculations.

Geometry calculations on the primary or source leg of the calculation are carried out to the radius of a pseudo-sphere imposed on the problem geometry. The radius of this pseudo-sphere (a SCAP input quantity) sets the upper limit in radius of the integration of scatter points along the source ray and must include all scatter zones to be considered.

An explanation of the geometry calculations for the source ray only will be described here but the scatter ray can be inferred by substituting the scatter point for the source point.

Geometry and material penetration calculations in SCAP are 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 SCAP code calculates the "line-of-sight" distance (path length) through each material in each zone along a source ray to the radius of the pseudo-sphere.

Subsequent sections describe the techniques used in describing the geometry by surfaces and zones and solving geometry dependent quantities in a SCAP problem.

Surfaces

The geometry of the problem can include the following types of quadratic equation surfaces:

- 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:

$$A(X^2) + B(Y^2) + C(Z^2) + X_0X + Y_0Y + Z_0Z - D = 0.0$$

$$A(X-X_0)^2 + B(Y-Y_0)^2 + C(Z-Z_0)^2 - D = 0.0$$

$$(X-X_0)^2 + (Y-Y_0)^2 - D = 0.0$$

$$X - D = 0.0$$

$$Y - D = 0.0$$

$$Z - D = 0.0$$

$$A(X^2) + B(Y)^2 + C(Z^2) + X_0X + Y_0Y + Z_0Z - D^2 = 0.0$$

$$A(X-X_0)^2 + B(Y-Y_0)^2 + C(Z-Z_0)^2 - D^2 = 0.0$$

$$(X-X_0)^2 + (Y-Y_0)^2 - D^2 = 0.0$$

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.

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 SCAP code requires the user 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 SCAP 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 a difficult task.

External zones in a SCAP 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 code 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 radius of the pseudo-sphere point (x_p, y_p, z_p).

With the direction cosines (α, β, γ) of the source ray known, 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:

$$V_{bZ} = A(x' - X_0)^2 + B(y' - Y_0)^2 + C(z' - Z_0)^2 + X_{0}x' + Y_{0}y' + Z_{0}z' - D$$
$$V_{bZ} = A(x' - X_0)^2 + B(y' - Y_0)^2 + C(z' - Z_0)^2 - D$$
$$V_{bZ} = (x' - X_0)^2 - (y' - Y_0) - D$$

$$V_{bZ} = x' - D$$
$$V_{bZ} = y' - D$$
$$V_{bZ} = z' - D$$
$$V_{bZ} = A(x' - X_0)^2 + B(y' - Y_0)^2 + C(z' - Z_0)^2 + X_0x' + Y_0y' + Z_0z' - D^2$$
$$V_{bZ} = A(x' - X_0)^2 + B(y' - Y_0)^2 + C(z' - Z_0)^2 - D^2$$
$$V_{bZ} = (x' - X_0)^2 - (y' - Y_0) - D^2$$

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.

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 crosssing 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 ray "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) continues until an "outside zone" is reached or until the radius of the pseudo-sphere is reached. This source ray calculation is a repetitive calculation for each source ray.

3.7.4 Material Attenuation Calculations

The SCAP code performs material- and energy-dependent calculations at two points in the code logic.

These two separate calculations are:

- Calculation of material penetration on the source leg to each scatter point 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.
- Material penetration on the scatter leg to the detector point for each group using input neutron or photon cross sections or calculated photon cross sections at source energy or the scattered energy.

Each of the categories of calculations is described in the following discussion.

<u>Material Attenuation Calculation</u>

In Section 3.7.3 the technique of calculating the geometry ray trace was described. The calculated zone path lengths, ρ_z, on each ray trace from a source point to a scatter point (or a scatter point to a detector point) are combined with the macroscopic neutron or photon cross sections to provide the total mean free paths of material penetration on the ray trace. The total mean free paths of material traversed on the line-of-sight to the scatter or detector point are used in an exponential attenuation function to provide the material attenuation.

Two techniques of specifying neutron and photon cross sections are provided in the SCAP code. The user may input groupwise 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 to the point of interest (scatter or detector point) b(E) is defined by:

$$b(E) = \sum_{z=1}^{Z} \Sigma_z(E) \rho_z$$

where the cross sections, $\Sigma_z(E)$, are macroscopic zone material data.

In the calculation of the material penetration to a scatter point, the material attenuation is based on cross section data supplied by the user for the source energies or in the case of single scatter calculations, cross sections interpolated from a table of values.

The input to the SCAP code includes the energies at which the cross sections are to be evaluated and placed in a table. In gamma ray single scatter or gamma ray albedo calculations the input or calculated values of the cross sections are the absorption cross sections. In the case of neutron albedo calculation, the input cross sections are the total or removal cross sections of the elements and materials.

The optional calculation of the gamma ray absorption cross sections involves the use of a mixture material - component material table to specify the density (grams per cubic centimeter) of elements in each mixture material. These data are combined with gamma ray cross sections calculated from a microscopic library tape with internal calculations to form macroscopic absorption 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 gamma ray cross sections as follows:

$$\Sigma_n(E) = \sum_{c} \sigma_c(E) \; A_{mc}$$

A "void" is defined as a mixture material in which all component materials are with zero density.

The technique of calculating the macroscopic 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.

Basic Library Data

The basic library tape required for the SCAP code is in a format-generated by the GAMLEG-W code.[6]

The basic data were obtained from Reference 5. These data were compiled in tabular form for the 51 elements shown in Table 2-4 as pointwise data at energy points in the range of 0.01 MeV to 20.0 MeV. Only pair-production and photo-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 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 3-7. 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 SCAP 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, $\sigma(E_i)$, and pair production cross sections, $\sigma_{pp}(E_i)$. This data is then interpolated to 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 SCAP code provides total cross section data at source or scatter energy points only. The interpolated absorption data, $\sigma_a(E_g)$, described earlier is combined with the Compton scatter cross section, $\sigma_c(E)$, to provide the total cross section $\sigma_t(E)$. 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.

The total cross section, $\sigma_t(E_g)$, in barns, is then defined as,

$$\sigma_t(E_g) = \sigma_a(E_g) + Z \cdot \sigma_c(E_g)$$

where Z is the electrons/cc of the material.

TABLE 3-7

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. (I3,2E12.5)	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.

3.7.5 Scatter Point Calculations - Single Scatter

Calculations of the scatter point density in a SCAP calculation are based on the source leg line-of-sight path length through a scatter zone in single scatter calculations or the first boundary crossing of an albedo zone in an albedo scatter calculation. A scatter zone in SCAP is a zone whose material number is input as a positive zone. All non-scatter or non-albedo zones must have a negative material number. The position of the scatter points are then determined from the line-of-sight direction cosines and the position along the line-of-sight (radial distance along the source leg).

The SCAP single scatter method of determining scatter point density (electrons/cm^3) of the zone material and an input quantity, DED, to the code.

The number of scatter points along the source leg line-of-sight, ρ_z, through zone, z, is calculated as follows:

$$N_p = \left[\frac{\rho_z \; N_z^e}{D}\right] + 1$$

where N_p = the number of scatter points in the distance ρ_z,

ρ_z = the source leg line-of-sight distance through zone z,

N_z^e = the electron density (number of electrons/cm^3) zone z,

D = the input quantity, DED, which defines the average electron depth penetration electrons/cm^2, per scatter point.

The quantity in brackets is evaluated as an integer, hence the value of N_p is one or greater.

The scatter point coordinates in the zone are then determined for the radial distance on the source leg at the zone entry point and the value of N_p as follows:

$$\rho_p = \rho_o + \left(n - \frac{1}{2}\right) \cdot \left(\frac{\rho_z}{N_p}\right)$$

where ρ_p = the radial distance or the source leg at the scatter point, ρ,

ρ_o = the radial distance on the source leg at the zone entry point.

The coordinates of the scatter point (x_p, y_p, z_p) then follow as;

$$x_p = x_s + \alpha \rho_p$$

$$y_p = y_s + \beta \rho_p$$

$$z_p = z_s + \gamma \rho_p$$

The scatter volume associated with the scatter point used to calculate the total scatter zone volume and the magnitude of the scatter source is a calculator from the solid angle interval in spherical coordinate system assigned to the source leg and the radial interval on the source leg bounding the scatter point as follows:

$$\Delta \upsilon_p = \Delta \theta_i (\cos \phi_{iH} - \cos \phi_i) \quad (\rho_{\ell+1}^3 - \rho_\ell^3)$$

where $\Delta \upsilon_p$ = the scatter volume at scatter point ρ,

$\Delta \theta_i$ = the azimuthal angular width of the source leg solid angle in radians, $\theta_{i+1} - \theta_i$,

ϕ_{i+1}, ϕ_i = the polar angle limits of the source leg solid angle of source ray i,

$\rho_{\ell+1}$, ρ_ℓ = the radial limits along the source leg defining the scatter point interval

$$\rho_{\ell+1} = \rho_p + \frac{\rho_z}{N_p}$$

$$\rho_\ell = \rho_p - \frac{\rho_z}{N_p}$$

This scatter source volume is used in determing the total scatter volume by zone (a printed output value) and the total number of electrons at a scatter point, $N_z^e \Delta v_p$.

The scattering probability in the SCAP single scatter method uses the Klein Nishina for scattering through the angle formed by the direction of the source leg at the scatter leg direction. This calculation involves the direction cosines of the scatter leg defined from the coordinates of the scatter point (x_p, y_p, z_p) and the detector point (x_D, y_D, z_D) as follows:

$$\alpha_p = \frac{y_D - y_p}{\rho_D}$$

$$\beta_p = \frac{y_D - y_p}{\rho_D}$$

$$\gamma_p = \frac{z_D - z_p}{\rho_D}$$

where ρ_D = the line-of-sight distance from a scatter point to the detector point defined as,

$$\rho_D = (x_D - x_p)^2 + (y_D - y_p)^2 + (z_D - z_p)^2$$

The angle of scatter, ψ is then defined by the equation,

$$\psi = \cos^{-1} (\alpha_s \bullet \alpha_p + \beta_s \bullet \beta_p + \gamma_s \bullet \gamma_p)$$

The scattering probability and the scatter energy is calculated for the differential form of the Klein Nishina equation for Compton scattering of a gamma ray by the following equations,

$$E' = E \bullet \left[\frac{1}{1 + \frac{E}{0.511} \bullet (1 - \cos \psi)} \right]$$

$$\frac{d\sigma}{d\Omega}(\psi, E) = C \bullet \left(\frac{E'}{E}\right)^2 \bullet \left[\frac{E}{E'} + \frac{E'}{E} - \sin\psi\right]$$

where E' = the scattered gamma ray energy,

E = the incident gamma ray energy,

$\frac{d\sigma}{d\Omega}(\psi, E)$ = The differential scatter cross section per electron,

C = the constant 0.03970562.

The total scatter source at the scatter point P in zone z for scatter toward the detector point D is defined as:

$$q_p(\psi, E') = \frac{\Delta\upsilon_p \ \frac{d\sigma}{d\Omega}(\psi, E) \bullet \frac{E'}{E} \bullet N_z^e \bullet q_s(\overline{\theta}, \overline{\phi}, E) \bullet \exp(-b_p(E))}{\rho_p^2}$$

where $S_p(\psi, E')$ = the scatter source at point p.

3.7.6 Scatter Point Calculation - Albedo Scatter

Calculation of the scatter point density in a SCAP albedo scatter calculation are based on the source leg line-of-sight entry point into an albedo zone. The user specifies the zones to be albedo zones by the sign of the material in the zone. At the entry point the code calculates the angle of incidence as the angle the source leg line-of-sight forms with the normal to the surface and the angle of reflection as the angle of the scatter leg line-of-sight forms with the normal to the surface. This calculation uses the boundary surface equations to calculate the direction cosines of the normal to the surface ($\alpha_N, \beta_N, \gamma_N$) and the angle of meridian, ψ_o, is defined by the equation:

$$\psi_I = \alpha_N \alpha_s + \beta_N \beta_s + \gamma_N \gamma_s$$

where $(\alpha_s, \beta_s, \gamma_s)$ = the direction cosines of the source leg.

The angle of reflection is defined by the equation:

$$\psi_R = \alpha_N \alpha_D + \beta_N \beta_D + \gamma_N \gamma_D$$

where $(\alpha_D, \beta_D, \gamma_D)$ = the direction cosines of the scatter leg.

The albedo scatter probability is then defined by one of three techniques as given by the following equations:

$$\alpha(E) = \beta(E) \bullet \cos^{(2/3)} \psi_I \bullet \cos \psi_R$$

$$\alpha(E) = \beta(E) \bullet \left[1.625 - 0.652 \bullet \cos^{(2/3)} \psi_I \right] \bullet \cos \psi_R$$

$$\alpha(E) = \beta(E) \bullet \cos \psi_R$$

where $\alpha(E)$ = the albedo scatter fraction per interaction for source energy, E,
$\beta(E)$ = the normal incidence-normal reflection albedo for source energy, E.

The first two equations above are interacted for use in neutron albedo calculations[8] and the third equation is intended for gamma ray albedos[8].

The scatter source for the albedo method is then the product of the surface area of the source leg solid angle interval at the radius of the entry point into the albedo zone;

$$\Delta a_p = \Delta\theta_i \bullet (\cos \phi_{\theta+1} - \cos_i \phi_i) \; \rho_p^2$$

where Δa_p = the area of the solid angle at the entry point,

ρ_p = the line-of-sight distance from the source point to the zone entry point.

The albedo scatter source is then given by:

$$q_p(E) = \frac{\alpha(E) \bullet \Delta a_p \bullet q_s(\overline{\theta}, \phi, E) \bullet \exp[-b(E)]}{\rho_p^2}$$

In addition to the above calculated result, the scatter area by albedo zone is calculated as the sum of all source angle intervals and the totals are printed output.

3.7.7 Scatter Leg Calculations

The scatter leg calculations performed by the SCAP code include the material attenuation and the effect of gamma ray multiple scatter by a buildup factor. Material attenuation and the scatter leg is an exponential function and is based on the scattered gamma ray energy in the single scatter method or the source energy in the gamma ray or neutron albedo scatter method.

Macroscopic cross section data for the gamma ray scatter leg calculations are obtained for interpolation of the macroscopic absorption cross section data to the scattered energy (or source energy is albedo scatter) and the calculation of the Klein Nishina equation at the scattered or source energy. The total macroscopic cross section is then calculated in the identical fashion as the source leg data. The material attenuation function is an exponential function with the mean free paths of material traversed on the scatter leg as the exponent. Material attenuation in neutron albedo scatter calculations are calculated in a similar fashion except that the total or removal cross section must be input as macroscopic data and the interpolation of this data to the source energy is performed.

The application of a buildup factor to account for multiple scattering on the scatter leg is performed in SCAP. The user of the code specifies the type of buildup in input and the code evaluates the buildup factor from bivariant polynominal data in a library included in the codes based on the mean free paths of material depth penetration on the scatter leg and the energy of the particle or flux on the scatter leg. The flux arriving at the detection point from the scatter point is calculated as follows:

$$\Phi(E) = \frac{B(E') \bullet q_p(E', \psi) \bullet \exp\left[-b(E')\right]}{\rho_s^2}$$

where

$\Phi(E')$ = the energy or particle flux for energy E' at the detector point due to scatter at point P,

$B(E')$ = the buildup factor on the scatter leg for gamma rays of energy E' and material specified in the SCAP input,

$b(E')$ = the mean free paths of material penetration on the scatter leg for energy E',

β = the line-of-sight distance from the scatter point to the detector point.

3.7.8 Detector Point Calculations

The scattered flux at the detector point, $\Phi(E')$, for each scatter point is summed into final result tables as a function of scatter zone and scattered energy for single scattered calculations or source energy for albedo calculations. The SCAP user specifies flux group energy boundaries for this summary result. These data are obtained with and without the buildup factor $B(E')$ applied. These data are obtained for each point source.

The dose rate at the detector point is obtained by converting the detector flux to dose rate in Rads (carbon)/hour for gamma rays or input units for neutrons summing over group or energy to calculate the total dose rate contribution for each scatter event. The dose rate conversion factor for gamma rays is obtained by interpolation of a table of values internal to SCAP using the scattered or source energy. Neutron dose conversion is a required input data array.

The final summary results of the code at the detector point are the summation of the detector point dose rates from scatter points as a function of polar angle source ray number, (with and without buildup), scatter zone, and composition. This latter summation is provided for problems with many zones of the same material composition (e.g., a series of liquid hydrogen zones). In addition the scatter volume by zone or the scatter area by albedo zone is calculated from summation of scatter point volumes or areas. An additional quantity calculated in the SCAP code is the energy deposition in the scatter zones. This result is obtained only for single scatter calculations and is calculated using; the uncollided flux at the scatter point, the buildup factor evaluated for the material penetration on the source leg and at the source energy, the scatter point volume, and the zone material energy absorption cross section evaluated at the source energy. The energy absorption cross section is calculated from the material absorption cross section and the Klein Nishina formula for Compton energy absorption cross section.

A final detector point result is the direct (uncollided) flux result. This value is calculated using the meridian ring value of the source data interpolated to the source point-to-detector point polar angle. Material and inverse square attenuation and dose conversion is applied to obtain the direct dose rate. The sum of the scattered result with buildup and the direct result is provided as the total result.

Since the SCAP code contains the option for multiple point sources, a summation of the total, direct, and scattered dose rates at the detector point is calculated and printed. These results contain the scattered result with buildup applied to the result.

4.0 REFERENCES

1. R. K. Disney and M. A. Capo, WANL-PRR(LL)-010, Volume 4, "Synthesis of Calculational Methods for the Design and Analysis of Radiation Shields for Nuclear Rocket Systems, KAP-V, The Point Kernel Attenuation Program," June 1967.

2. Edwards, W. E. et. al., Shielding Computer Programs 14-0 and 14-1, Reactor Shield Analysis, General Electric Co., ANPD, XDC 59-2-16, January 23, 1959.

3. Krumbrin, A. D., Summary of NDA Unclassified Results of Moments Calculation for the Penetration of Neutrons Through Various Materials, Nuclear Development Corporation of America, NDA 92-2, August, 1957.

4. Capo, M. A., Gamma Ray Absorption Coefficients for Elements and Mixture, General Electric Co., ANPD, XDC 59-10-19, September 28, 1959.

5. Storm, E., et. al., Gamma Ray Absorption Coefficients for Elements 1 Through 100 Derived from Theoretical Values of the National Bureau of Standards, Los Alamos Scientific Laboratory, LA-2237, November, 1958.

6. R. G. Soltesz, R. K. Disney, and S. L. Ziegler, WANL-PR-(LL)-034, Volume 3, "Cross Section Generation and Data Processing Techniques," June 1970