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Westinghouse
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WANL-PR-(LL)-034

AUGUST 1970

FINAL PROGRESS REPORT

Contract No. NAS-8-24919

Control No. DCN 1 - X - 80 - 00056

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

VOLUME 4

ONE-DIMENSIONAL, DISCRETE ORDINATES TRANSPORT TECHNIQUE

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ONE-DIMENSIONAL, DISCRETE ORDINATES TRANSPORT TECHNIQUE

Prepared by:

R. G. Soltesz
R. K. Disney

ACKNOWLEDGMENT

The authors wish to express their appreciation to Ward W. Engle, Jr., of the Computer Technology Center of Union Carbide Corporation for his many constructive comments and assistance in the development of this version of the ANISN code.

FOREWORD

This report is Volume 4 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 ANISN-W Code 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.

Astronuclear Laboratory

ABSTRACT

The WANL version of the ANISN computer code for solving the one-dimensional, energy dependent, linear Boltzmann transport equation with general anisotropic scattering is described. The major improvements of the ANISN-W code over the ANISN code are 1) the inclusion of automated tape linkage of input and output data, and 2) the capability to input a distributed or shell source from cards and/or from tape. Detailed user information including problem setup, running time, boundary conditions, quadrature data, and mesh spacing requirements is described. In addition, requirements for cross section weighting, search calculations, activities, and stacked problems are given. Typical problem setup information is supplied as well as a description of the printed output. A sample problem card input and printout are included.

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1.0 INTRODUCTION

This report is Volume 4 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 ANISN-W, one-dimensional, discrete ordinates transport code.

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

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

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

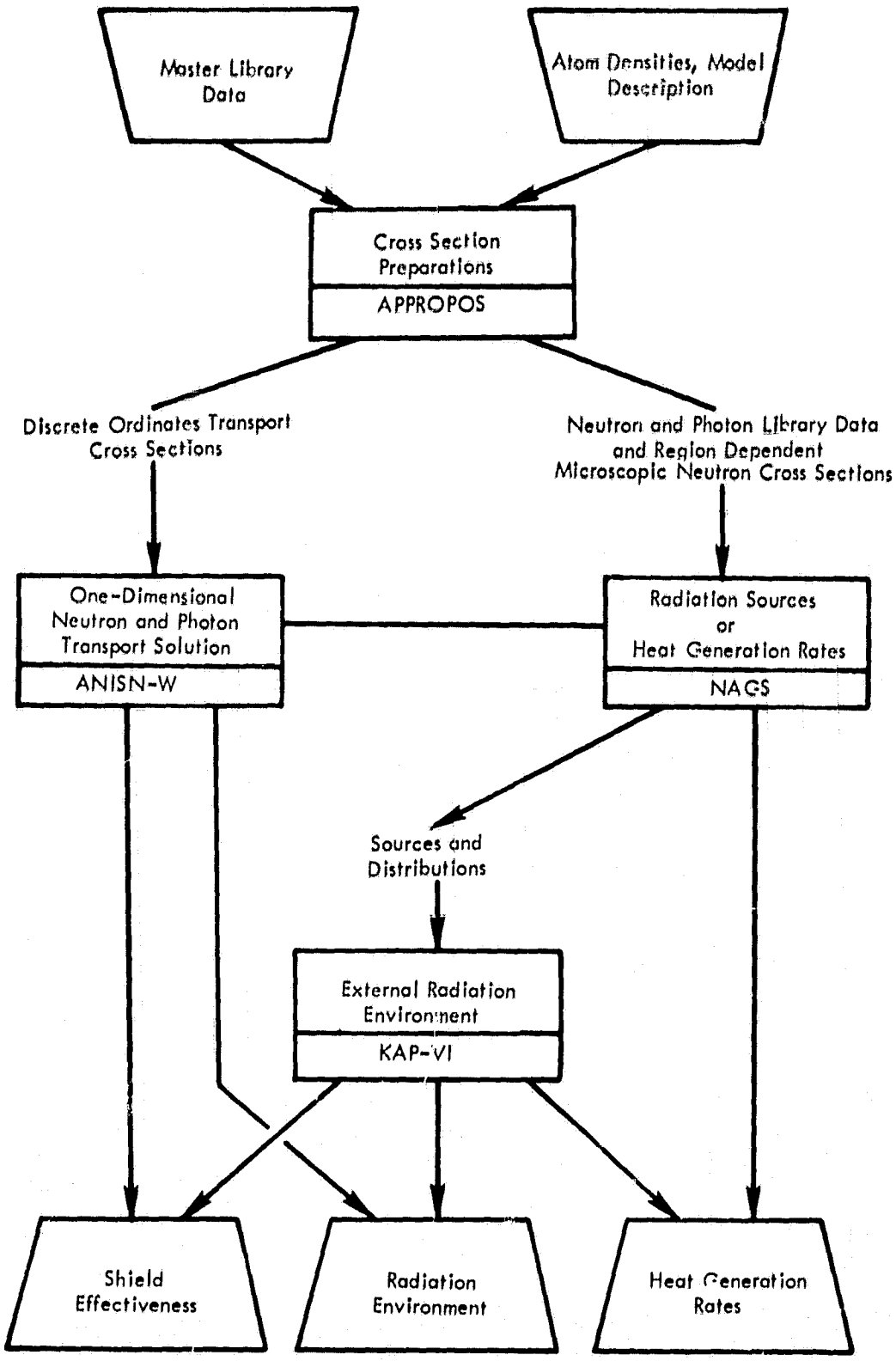

Figure 1-1. Flow Chart for Preliminary or Parametric Radiation Analysis

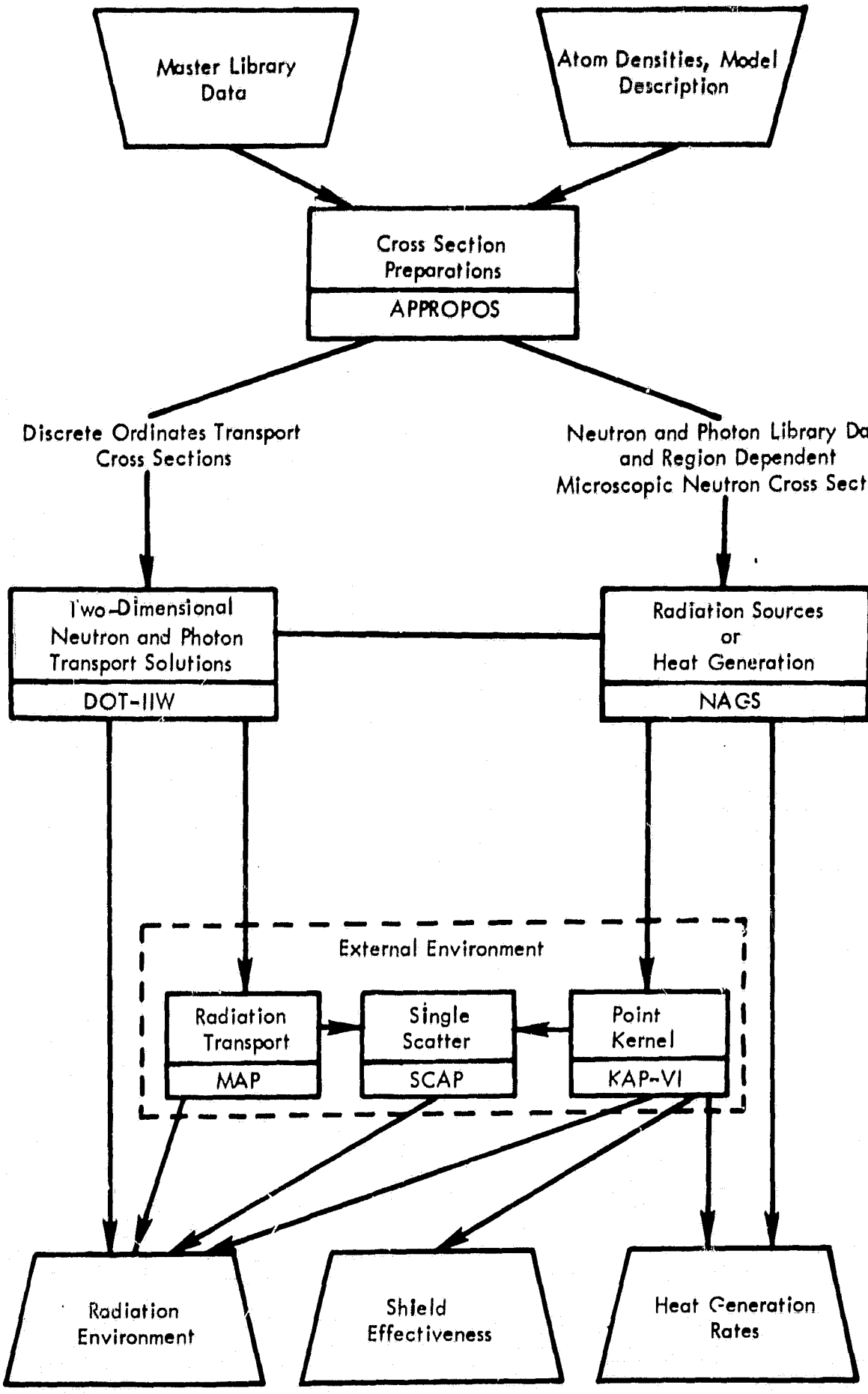

Figure 1-2. Flow Chart for Detailed Radiation Analysis

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

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

In the analysis of nuclear systems, a one-dimensional, transport theory code serves as the basis for many different types of calculations such as criticality, reactivity coefficients, critical size, preliminary shield design, flux attenuation, cross section group collapsing and upscatter removal. The need for a flexible yet efficient code to facilitate these calculations is obvious. For this reason, the ANISN-W program was developed.

ANISN-W is a multigroup discrete ordinate transport code that solves the energy dependent, one-dimensional, Boltzmann transport equation with general anisotropic scattering for slab, cylindrical or spherical geometries. In addition, multigroup flux distributions may be used to perform a group reduction of the cross sections.

The program described here is the latest WANL production version of the code. ANISN[1] was originally developed by W. W. Engle, Jr.,* and subsequently modified by the authors to satisfy the needs for a flexible production technique at WANL.

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

2.0 ANISN-W CODE

2.1 COMPUTER CODE SYNOPSIS

1. Name: ANISN-W[1,2]

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

3. Nature of Physical Problem Solved: ANISN-W solves the one-dimensional, energy dependent, linear Boltzmann transport equation with general anisotropic scattering for slab, cylindrical and spherical geometries. ANISN-W solves forward or adjoint, homogeneous or inhomogeneous problems. The inhomogeneous problems may have a fixed volume distributed source, or a specified angular dependent shell source at any mesh interval; fissions may be included for a subcritical system. Vacuum, reflective, periodic, white, or albedo boundary conditions may be specified. Time absorption calculations, concentration searches, outer radius searches, buckling searches, or zone thickness searches are also solved. Cross sections may be input from a library tape and/or from cards. Fixed distributed sources or shell sources may be input from cards and/or from tape. The code also includes space point scaling to accelerate the flux solution on inner iterations.

4. Method of Solution: The discrete ordinates or Carlson's S_n method using a diamond difference solution technique is employed.[3] The method is applicable to both neutron and gamma ray transport problems. The solution in the code will approach the exact solution of the Boltzmann equation with increasing orders of approximation as the space, angle, and energy mesh approaches differential size.

5. Restrictions on the Complexity of the Problem: The ANISN-W computer code utilizes variable dimensioning to facilitate efficient core data storage

allocation. Because of the variable dimensioning technique, on any given data array, no size restriction is imposed; only a size restriction on the length of the sum of all arrays is imposed. The amount of core data storage for a given problem may be exactly computed as indicated in the documentation.

6. Typical Running Time: The ANISN-W code computes approximately 1720 to 2930 angular fluxes per second on the UNIVAC-1108 computer.

7. Unusual Features of the Program: The code employs a general anisotropic scattering capability, variable dimensioning, and as a secondary calculation, the spatially dependent flux may be used as group weighting data to perform a group collapse of the cross sections.

8. Related or Auxiliary Programs: Cross sections may be supplied by the GAMB1T,[4] GAMLEG-W,[5] or APPROPOS[5] codes, as well as other cross section generation programs. Fixed distributed neutron or photon sources as well as energy deposition may be calculated with the NAGS[5] code.

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. G. Soltesz and R. K. Disney, WANL-PR-(LL)-034, Volume 4, "One-Dimensional Transport Technique," August 1970.
2. W. W. Engle, Jr., K-1693, "A Users' Manual for ANISN," March 1967.
3. F. R. Mynatt, F. J. Muckenthaler, and P. N. Stevens, CTC-INF-952, "Development of Two-Dimensional Discrete Ordinates Transport Theory for Radiation Shielding," August 1969.
4. G. Collier and G. Gibson, GAMB1T Program", WANL-TME-1752, April, 1968.

5. R. G. Soltesz, R. K. Disney and S. L. Zeigler, "WANL-PR-(LL)-034, Volume 3, "Cross Section Generation and Data Processing Techniques," August 1970.

11. Machine Requirements: The ANISN-W code is in production at MSFC on the UNIVAC-1108 computer with 65K core storage locations. The source program requires 16K decimal locations; the remaining locations are used for problem data storage. Up to seven tape or disk devices are required in addition to input, output, and punch disks.

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

13. Operating System Under Which Program is Executed: The ANISN-W code is operational under the EXEC8 Monitor System at MSFC.

14. Other Programming or Operating Information or Restrictions: None

15. Name and Establishment of Authors:

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Westinghouse Astronuclear Laboratory
P. O. Box 10864
Pittsburgh, Pa. 15236

2.2 INPUT DATA DESCRIPTION

2.2.1 Input Format

The input data for the ANISN-W code are divided into the following seven data sets:

A) Overall problem data storage allocation

B) Overall problem title and CPU time estimate

C) Overall problem parameters

D) Cross section data

E) Fixed source data

F) Flux or fission guess data

G) Remainder of data

The first data set is entered on a single, formatted card which is the first physical card of each problem deck. The second data set consists of a single card containing a problem descriptive title and Central Processor Unit (CPU) time estimate.

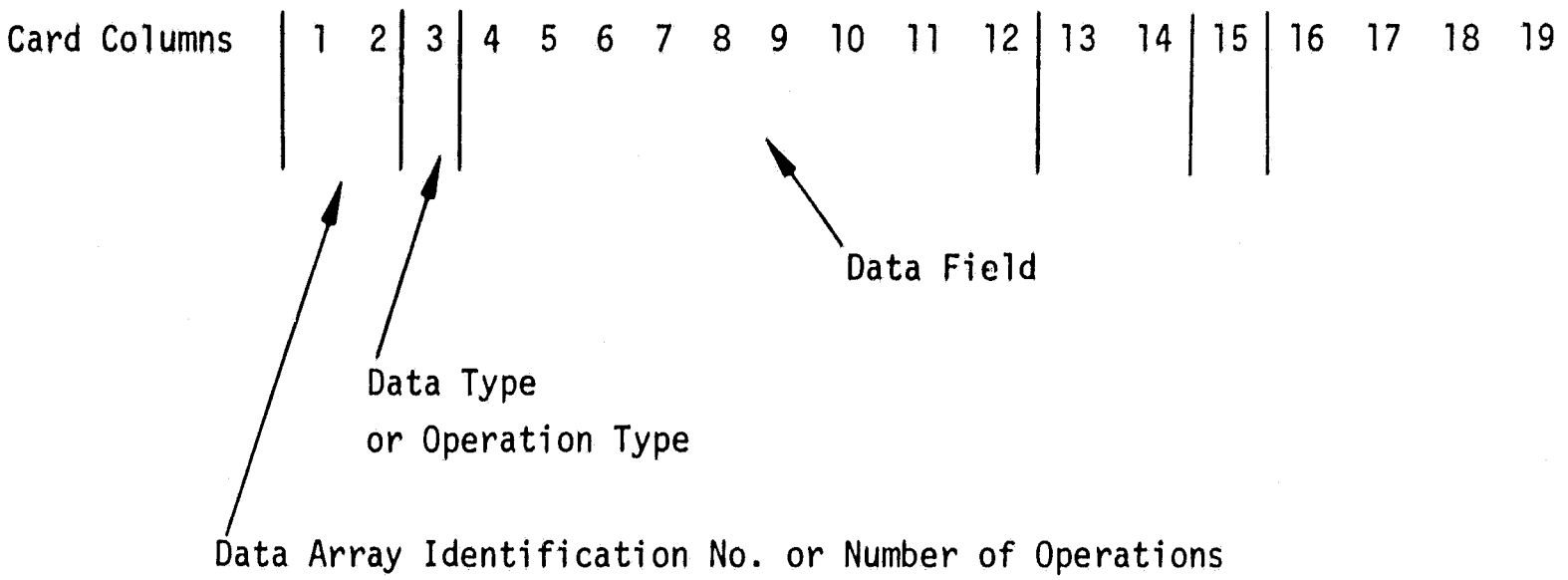
All remaining input data sets (C through G) of an ANISN-W problem are written in one of three FORTRAN type format capabilities. The integer data arrays (denoted by a dollar sign) must always be input in the standard ANISN-W format capability consisting of 6 fields of 12 columns in each field. Each field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

The non-standard WANL ANISN-W input formats which are shown in Figure 2-1 are included for the user's convenience and can only be used for any real (floating point) data array. These non-standard formats cannot include any operation type (fill, skip, interpolate, repeat, etc.) but can include blank fields on a card which cause the input routine to ignore the rest of the card, i.e., if the punched cross section data for a

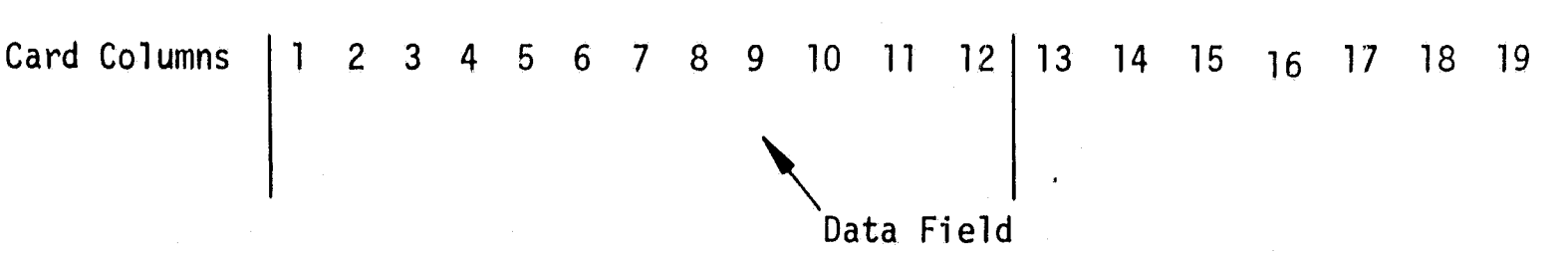
---

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

1. Standard: (6 (I2, A1, F9.0))



2. Non-Standard: (6E12.5), U Data Type



3. Non-Standard: (4(1X, E16.9, 1X)), V Data type or ODDK (FLOCOW)

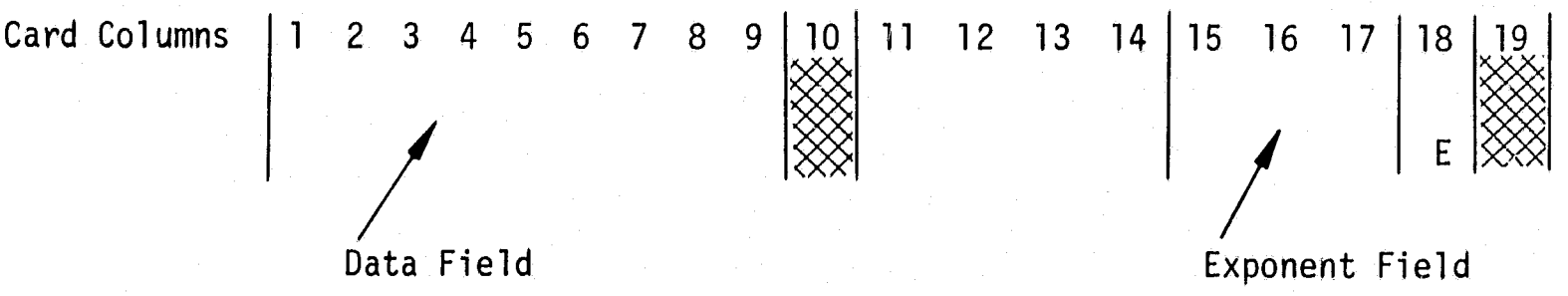


Figure 2-1. ANISN-W Input Formats

material include 117 entries (9 group by 13 table length) the set would be 19 full cards and a final card of 3 entries using the U format. ANISN-W would skip the last three fields and commence reading at the first data field of the next card.

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

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

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

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

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

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

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

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

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

F indicates that the remainder of the present array is to be Filled with the data entry in the third subfield. Any entry in the first subfield is ignored (e.g., F 1.0 will enter a flat flux guess for all groups and all points in the 3* or flux 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 associatied with the A. Any entry in the first subfield is ignored.

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

Z indicates the entry of Zeros. The integer entry in the first plus the third subfield indicates the number of successive zeros to be entered, (e.g., 10Z enters 10 zeros, Z 20 enters 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 reversed when they are repeated.

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

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

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

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

The following restrictions must be observed when writing input data for the ANISN-W program:

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

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

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

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

2.2.2 Input Data Instructions

This section describes the problem input data for the ANISN-W code. Section 2.3 presents a more detailed description of the data presented here. The quantity in slashes represents the array dimension, and the expression in braces is the condition requiring that array or set of arrays. Arrays or sets of arrays with the corresponding terminate (T) card which are not required should not be entered. If no condition is specified, the array is required. Note that a T must follow each of the five sets of arrays (C, D, E, F, or G) if that set is entered.

A. LIM1 card* - format (6X, I6) This card contains the maximum number of locations available for ANISN-W data (i.e., LIM1=4900_{10} on the UNIVAC-1108. EXEC8 computer with a 65K core memory storage available).

B. Title card - and CPU time estimate-format (12A6, E8.5) CPU time limit in seconds is entered in columns 73 - 80, inclusive. If columns 73 - 80 are left blank, the option of forcing the termination of a calculation with a full printout before the time limit is ignored. (See Section 2.3.1 for details.)

C. Parameters

15$ Integer parameters/36/

1. ID, problem ID
   If ID is greater than 1000000, disadvantage factors will be computed by group for each material which appears in the calculation.
2. ITH, 0 - forward calculation
   1 - adjoint calculation
3. ISCT, maximum order of scatter found in any zone (0/1/2. . ; P0/P1/P2. . scattering approximation in any zone) (19$ array specifies P_ℓ order by zone)

---

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

4. ISN, order of angular quadrature (even integer only, 2/4/6. . ; $S_2/S_4/S_6$...) If a diffusion theory solution is desired, set ISN=2 and enter S_2 quadrature data.

5. IGE, geometry parameter
   - 1 - slab
   - 2 - cylinder
   - 3 - sphere

6. IBL, left boundary condition
   - 0 - vacuum (no reflection)
   - 1 - reflection ($d\emptyset/dX=0$)
   - 2 - periodic (Angular flux leaving left boundary re-enters in the right boundary)
   - 3 - white/albedo (Some fraction returns isotropically)

7. IBR, right boundary condition, same options as IBL
8. IZM, number of zones or regions in the problem geometry (9$)
9. IM, number of mesh intervals in the problem geometry (8$)
10. IEVT, Type of calculation to be performed
    - 0 - distributed fixed source or shell source calculation (inhomogenous calculation)
    - 1 - k-calculation (eigenvalue (homogeneous) calculation)
    - 2 - a-calculation (time absorption calculation)
    - 3 - concentration search calculation
    - 4 - zone thickness search calculation
    - 5 - outer radius search calculation
    - 6 - buckling search calculation
11. IGM, number of energy groups in the calculation
12. IHT, position of Σ_{total} or $\Sigma_{transport}$ in cross section table.

13. IHS, position of Σ_{gg} (within-group scatter) in cross section table
14. IHM, length of cross section table
15. MS, cross section mixing table length (10$, 11$, and 12*)
16. MCR, number of cross section sets to be read from cards (14*, 14U, or 14V)
17. MTP, number of cross section sets to be read from tape (13$)

    Note: 1. Cross section tape is mounted on logical tape unit 14.

    2. Cross sections from cards are read in before those from tape.

    3. Each set of cross sections whether from cards, tape, or formed in the mixing table is assigned a unique number $\leq$ MT.

    4. If ID2=1, no 13$ or 14* array is input and MTP must be the total number of materials contained on the group independent cross section tape

18. MT, total number of materials (MCR + MTP + mixtures formed in cross section mixing table)
19. IDFM, 0 - density factors (21*) not used
    1 - density factors used
20. IPVT, 0 - no effect
    1 - enter K_o as PV (16*)
    2 - enter a_o as PV
21. IQM, 0 - no effect
    1 - enter distributed source (17*)
    2 - enter distributed source from tape 9 and enter the interval range to be used from tape 9 in the 17$ array (17$)

22. IPM, 0 - no effect

1 - enter shell source by group and angle (18*)

IM - enter shell source by interval, group, and angle

-1 - enter shell source from tape 9 and enter the mesh number containing the desired shell source in the 18$ array (18$)

23. IPP, interval number which contains shell source if IPM = 1 or -1
0 otherwise

24. IIM, Maximum number of inner iterations by group (suggested value, IIM > 20)

25. ID1, 0 - no effect

1 - print angular flux

2 - punch scalar flux by interval, zone leakage, and integral zone fluxes, and fission density by interval (punch in 6E12.5)

3 - both 1 and 2

26. ID2, 0 - no effect

1 - use specially prepared group independent cross section tape* (contains MTP materials) IDAT1 must be greater than zero when this specially prepared tape is used

27. ID3, 0 - no effect

N- compute N activities by zone

1 - ID3 must be >0 if ID4 > 0

28. ID4, 0 - no effect

1 - compute activities by interval

29. ICM, outer iteration maximum (Suggested value for K calculations, ICM=50) (Suggested value for source calculations with no upscatter, ICM=1)

---

* Prepared by the SATURN code.

30. IDAT1, 0 - all data in core (suggested option)

1 - cross sections and fixed sources stored on tape

2 - fluxes and currents on tape also

Note: 1. When IDAT1=1, or 2, the Peripheral Processor Unit (PPU) time and elapsed time increase significantly.

2. IDAT1 must be greater than zero when ID2=1.

31. IDAT2, 0 - no effect

If IDAT2 is greater than zero, the first IDAT2 outer iterations will be executed according to the specifications in the 24$ array.

32. IFG, 0 - no effect

1 - flux weight P_0 cross sections and current weight P_ℓ cross sections (L>0) (27$, 28$)

2 - flux weight P_ℓ cross sections ($L \geq 0$) (27$, 28$)

33. IFLU, 0 - step model used when linear extrapolation yields negative flux (mixed mode) (suggested option)

1 - use linear model only

2 - use step model only

34. IFN, 0 - enter fission guess (2* or 2U)

1 - enter flux guess (3* or 3U)

2 - use fluxes from previous case

35. IPRT, 0 - print cross sections

1 - do not print cross sections

36. IXTR, 0 - calculate P_ℓ scattering constants (Legendre coefficients, suggested option)

1 - read P_ℓ constants from cards (34*)

16* Floating point parameter/14/

1. EV, first guess for eigenvalue; see detailed notes for explanation.
2. EVM, eigenvalue modifier; see detailed notes for explanation
3. EPS, epsilon for lambda and upscatter convergence - precision desired (Suggested value, EPS = 0.0001. If small perturbations are under analysis, tighter convergence is required.)
4. BF, buckling factor
5. DY, cylinder or plane height for buckling correction (may include extrapolation distance)
6. DZ, plane depth for buckling correction
7. DFM1, transverse dimension for void streaming correction (does not include extrapolation distance, i.e., the physical distance)
8. XNF, normalization factor (If XNF=0.0, no normalization is done) (Suggested value, XNF=1.0)
9. PV, 0.0, k_o, or α_o according to IPVT = 0, 1, or 2 (for search problems, PV = desired eigenvalue)
10. RYF, λ_2 relaxation factor (suggested value, 0.5)
11. XLAL, pointwise flux convergence criterion, if entered. If XLAL is zero, then integral convergence tests are used with EPS as the criteria. (suggested value, 2.0 * EPS)

12. XLAH, upper limit for $\left| 1.0 - \lambda_1 \right|$ used in linear search

13. EQL, eigenvalue change epsilon for search calculations, zero otherwise.

14. XNPM, new parameter modifier for search calculations, zero otherwise.

Terminate Card

D. Cross Section Data $\{ID2 = 0\}$

13$ Library ID number/MTP/ $\{MTP > 0\}$ Cross section tape can be generated by APPROPOS, GAMLEG-W, SATURN, or a previous ANISN-W calculation. Data entered here must be in same order as the data contained on Tape 14.

14* Cross sections/IHM x IGM x MCR/ {MCR > 0: standard ANISN format}

Terminate Card

E. Fixed Source $\{IEVT = 0 \text{ and } ID2 < 2\}$

17* Distributed source /IGM x IM/ $\{IQM = 1\}$

17$ Interval range (K to M, inclusive) containing the distributed source from tape 9, $K < M \leq IM$ /2/
$\{IQM = 2, IPM = 0\}$

18* Shell source /IGM x IPM x MM*/ $\{IPM > 0\}$

18$ Mesh line, M, containing the shell source from tape 9 which is to be applied to the right boundary of mesh interval IPP/1/ $\{IPM = -1, IQM = 0\}$

Terminate Card

F. Flux or Fission Guess $\{IFN < 2\}$

2* Fission density /IM/ $\{IFN = 0\}$

or

3* Flux guess /IGM x IM/ $\{IFN = 1\}$

or

3U Flux guess/IGM x IM/(6E12.5 format, ANISN punched output)

Terminate Card

G. Remainder of Data

1* Fission spectrum data /IGM/

The sum of the entries in the 1* array should equal 1.0 for K calculations.

4* Mesh line coordinates defining the IM mesh intervals /IM + 1/

5* Representative velocities by group /IGM/ (Suggested values, F 1.0, except for α calculations, where a search for the amount of 1/v absorber to achieve criticality is made)

6* Angular quadrature weights /MM/

7* Angular quadrature cosines /MM/

8$ Zone numbers by mesh interval /IM/

9$ Material numbers by zone /IZM/

If a 9$ entry is negative, no buckling (transverse leakage) correction is made for that zone.

---

* MM = ISN + 1 for plane or sphere

= (ISN x (ISN + 4))/4 for cylinder

10$ Mixture material numbers in mixing table /MS/ {MS > 0}

11$ Component material numbers of mixtures in mixing table /MS/ {MS > 0}

12* Atom densities of component materials in mixing table /MS/ {MS > 0}

19$ Order of scatter by zone /IZM/ {ISCT > 0}

20* Radius modifiers by zone /IZM/ {IEVT = 4}

21* Density factors by interval /IM/ {IDFM = 1}

22$ Material numbers for activities /ID3/ {ID3 > 0}

23$ Cross section table position for activities /ID3/ {ID3 > 0}

24$ Diffusion or infinite media calculation markers /IGM/ {IDAT2 > 0}

0 - Use the S_n theory calculation for this group

1 - Use the diffusion theory calculation for this group

2 - Use the infinite homogeneous media calculation for this group

If convergence is not obtained after IDAT2 outer iterations, the problem continues using the S_n theory calculation for all groups until convergence is obtained or ICM is reached.

25* Albedo by group - right boundary /IGM/ {IBR = 3}

26* Albedo by group - left boundary /IGM/ {IBL = 3}

27$ Few group parameters /6/ {IFG > 0}

1. ICON 0 - no effect

1 - micro cross sections desired

(NOTE: Mixing table, MS > 0, must be in problem)

2 - macro cross sections desired (minus implies cell weighting)

3 - both macro and micro cross sections desired (minus implies cell weighting of the macro data)

Note: 1 - a maximum of 200 cross section sets may be processed

2 - the processed cross sections are placed on tape 4 for use in subsequent ANISN-W or DOT-IIW calculations

3 - the macroscopic data precede the microscopic data when ICON = 3. The data are processed in the order given in the 9$ and 11$ arrays with zero entries excluded.

2. IHTF position of Σ_{total} or Σ_{tr} in weighted cross sections

3. IHSF position of Σ_{gg} in weighted cross sections before upscatter removal (minus implies upscatter removal)

4. IHMF table length of weighted cross sections

5. IPUN 0 - no effect

1 - punch weighted cross sections on cards

6. IGBF Number of neutron groups in problem before group collapsing. This parameter is important for coupled, neutron-photon, cross section collapsing

28$ Few group number for each multigroup /IGM/ $\{IFG > 0\}$

34* P_ℓ scatter constants /JT* x MM/ {IXTR = 1}

Terminate Card

This concludes the required input data for one case; stacked problems would begin with the title card. Details on how to stack problems are given in Section 2.3.

---

*JT = ISCT for plane or sphere.
JT = (ISCT x (ISCT + 4))/4 for cylinder. Note: JT is truncated to the next lower integer for cylinders when ISCT is odd.

2.2.3 Problem Size Determination

To determine the number of data locations required for a given problem, each of the expressions in the two columns below should be evaluated and summed.

(240)	(IM) (IDFM)
(IGM + 1) (2)	(IM) (IGM) if IDAT1 < 2
(IGM) (5)	(IM) if IDAT1 = 2
(IM) (11)	(IHP)* (IGM) (MT) if IDAT1 = 0
(IM + 1) (4)	(IHP) (MT) if IDAT1 > 0
(MM)*** (5)	(IM) (IGM) (IQM) if IDAT1 = 0
(IZM) (3)	(IM) (IQM) if IDAT1 > 0
	(IPM) (MM) (IGM) if IDAT1 = 0
	(IPM) (MM) if IDAT1 > 0
(MS) (3)	(IGM) if IBR = 3
(MTP)	(IM) (MM)
(ID3) (2)	(IGM) if IBL = 3
(IFG) (5)	(MM) (JT)**if ISCT > 0
(IFG) (IGM)	(IM) (JT) (IGM) if ISCT > 0 and IDAT1 < 2
(IM + 1) (MM) (5)	(MM) (IGM) if IDAT1 < 2
(IM) (JT) (2)	(MM) if IDAT1 = 2
(IM) (JT) + 1	(IM) (ISCT)
(IGM) (IDAT2)	(IM) (JT) if ISCT > 0 and IDAT1 = 2

2.2.4 Description of Quadrature Data Sets

In the solution of the Boltzmann transport equation, integration over the $\vec{\Omega}$ direction variable is necessary. In obtaining a numerical solution in the ANISN-W

---

* IHP = IHM if there is no upscatter; IHP = IHM+1 if there is upscatter.

** JT = ISCT for plane or sphere; JT = (ISCT x (ISCT + 4))/4 for cylinder.
If ISCT = 0, JT = 1 in the equations above

*** MM=ISN+1 for plane or sphere; MM = (ISN x (ISN+4))/4 for cylinder.

code, this integration is performed by mechanical quadrature, where the continuous variable, $\vec{\Omega}$, is represented by a set of discrete directions (Ω_s) and a corresponding set of weights (p_s). These directions are then equivalent to a set of points upon a unit sphere with origin at R. In those cases where the azimuthal $\vec{\Omega}$ component can be eliminated, the mechanical quadrature representation is achieved using a set of direction cosines (μ_m) for the discrete directions (Ω_s) and a set of level weights (w_m) for the point weights (p_s) over the level m.

The requirements for rotation-reflection invariance with respect to 90-degree axis rotations and with respect to reflections about an axis, axes, and the origin are important concepts in the selection of a generalized quadrature data set. It is convenient and desirable to use a standard set of mechanical quadrature data that in no way biases the results with respect to geometrical axis. For this reason, a set of completely symmetric quadrature data sets satisfying certain even moment conditions[2] as well as rotational invariance were developed[3] and calculated in the form necessary for use in the ANISN code. These sets are presented in Table 2-1 and Table 2-2 for plane and cylindrical one-dimensional geometries, respectively. The ANISN code requires that:

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

that:

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

and that:

(3) $$\mu_m \neq 0.0 \text{ for all } m$$

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

TABLE 2-1

PLANE GEOMETRY

Completely Symmetric Quadrature Sets Satisfying Even Moment Conditions, for Plane Geometry (Slab, Sphere)

	Direction Cosines (μ_m)	S_n		Weights (W_m)
1	-1.00	S_2	1	0.0
2	-.57735		2	0.500
3	+.57735		3	0.500
1	-.9367418	S_4	1	0.0
2	-.8688903		2	.1666667
3	-.3500212		3	.3333333
4	+.3500212		4	.3333333
5	+.8688903		5	.1666667
1	-.9637974	S_6	1	0.0
2	-.9261808		2	.0880631
3	-.6815076		3	.1572071
4	-.2666355		4	.2547298
5	+.2666355		5	.2547298
6	+.6815076		6	.1572071
7	+.9261808		7	.0880631
1	-.9759000	S_8	1	0.0
2	-.9511897		2	.0604938
3	-.7867958		3	.0907407
4	-.5773503		4	.1370371
5	-.2182179		5	.2117284
6	+.2182179		6	.2117284
7	+.5773503		7	.1370371
8	+.7867958		8	.0907407
9	+.9511897		9	.0604938
1	-.9859208	S_{12}	1	0.0
2	-.9716377		2	.0353813
3	-.8722706		3	.0558811

TABLE 2-1 (Cont'd)

	Direction Cosines (μ_m)	S_n		Weights (W_m)
4	-.7600210		4	.0624786
5	-.6280191		5	.0631890
6	-.4595476		6	.1190886
7	-.1672126		7	.1639814
8	+.1672126		8	.1639814
9	+.4595476		9	.1190886
10	+.6280191		10	.0631890
11	+.7600210		11	.0624786
12	+.8722706		12	.0558811
13	+.9716377		13	.0353813
1	-.9902984	S_{16}	1	0.0
2	-.9805009		2	.0244936
3	-.9092855		3	.0413296
4	-.8319966		4	.0392569
5	-.7467506		5	.0400796
6	-.6504264		6	.0643754
7	-.5370966		7	.0442097
8	-.3922893		8	.1090850
9	-.1389568		9	.1371702
10	+.1389568		10	.1371702
11	+.3922893		11	.1090850
12	+.5370966		12	.0442097
13	+.6504264		13	.0643754
14	+.7467506		14	.0400796
15	+.8319966		15	.0342569
16	+.9092855		16	.0413296
17	+.9805009		17	.0244936

TABLE 2-2

CYLINDRICAL GEOMETRY

Completely Symmetric Quadrature Sets Satisfying Even Moment Conditions For Cylindrical Geometry (Cylinder)

	Direction Cosines (μ_m)	S_n		Weights (W_m)
1	-1.0000	S_2	1	0.0
2	-.57735		2	0.500
3	+.57735		3	0.500
1	-.4950046	S_4	1	0.0
2	-.3500212		2	.1666666
3	+.3500212		3	.1666666
4	-.9367418		4	0.0
5	-.8688903		5	.1666667
6	-.3500212		6	.1666667
7	+.3500212		7	.1666667
8	+.8688903		8	.1666667
1	-.3770795	S_6	1	0.0
2	-.2666355		2	.0880631
3	+.2666355		3	.0880631
4	-.7318110		4	0.0
5	-.6815076		5	.0786035
6	-.2666355		6	.0786035
7	+.2666355		7	.0786035
8	+.6815076		8	.0786035
9	-.9637974		9	0.0
10	-.9261808		10	.0880632
11	-.6815076		11	.0786035
12	-.2666355		12	.0880632
13	+.2666355		13	.0880632
14	+.6815076		14	.0786035
15	+.9261808		15	.0880632
1	-.975900	S_8	1	0.0
2	-.9511897		2	.0604938
3	-.7867958		3	.0453704
4	-.5773503		4	.0453704
5	-.2182179		5	.0604938

TABLE 2-2 (Cont'd)

	Direction Cosines (μ_m)	S_n		Weights (W_m)
6	-.3086067		6	0.0
7	-.2182179		7	.0604938
8	+.2182179		8	.0604938
9	-.6172134		9	0.0
10	-.5773503		10	.0453704
11	-.2182179		11	.0453704
12	+.2182179		12	.0453704
13	+.5773503		13	.0453704
14	-.8164965		14	0.0
15	-.7867958		15	.0453704
16	-.5773503		16	.0462962
17	-.2182179		17	.0453704
18	+.2182179		18	.0453704
19	+.5773503		19	.0462962
20	+.7867958		20	.0453704
21	+.2182179		21	.0604938
22	+.5773503		22	.0453704
23	+.7867958		23	.0453704
24	+.9511897		24	.0604938
1	-.2364743	S_{12}	1	0.0
2	-.1672126		2	.0353813
3	+.1672126		3	.0353813
4	-.4890236		4	0.0
5	-.4595476		5	.0279406
6	-.1672126		6	.0279406
7	+.1672126		7	.0279406
8	+.4595476		8	.0279406
9	-.6498985		9	0.0
10	-.6280191		10	.0186688
11	-.4595476		11	.0251410
12	-.1672126		12	.0186688
13	+.1672126		13	.0186688
14	+.4595476		14	.0251410
15	+.6280191		15	.0186688
16	-.7781979		16	0.0
17	-.7600210		17	.0186688
18	-.6280191		18	.0129257
19	-.4595476		19	.0129257
20	-.1672126		20	.0186688
21	+.1672126		21	.0186688
22	+.4595476		22	.0129257

TABLE 2-2 (Cont'd)

	Direction Cosines (μ_m)	S_n		Weights (W_m)
23	+.6280191		23	.0129257
24	+.7600210		24	.0186688
25	-.8881531		25	0.0
26	-.8722706		26	.0279406
27	-.7600210		27	.0251410
28	-.6280191		28	.0129257
29	-.4595476		29	.0251410
30	-.1672126		30	.0279406
31	+.1672126		31	.0279406
32	+.4595476		32	.0251410
33	+.6280191		33	.0129257
34	+.7600210		34	.0251410
35	+.8722706		35	.0279406
36	-.9859208		36	0.0
37	-.9716377		37	.0353813
38	-.8722706		38	.0279406
39	-.7600210		39	.0186688
40	-.6280191		40	.0186688
41	-.4595476		41	.0279406
42	-.1672126		42	.0353813
43	+.1672126		43	.0353813
44	+.4595476		44	.0279406
45	+.6280191		45	.0186688
46	+.7600210		46	.0186688
47	+.8722706		47	.0279406
48	+.9716377		48	.0353813
1	-.1965146	S_{16}	1	0.0
2	-.1389568		2	.0244936
3	+.1389568		3	.0244936
4	-.4161729		4	0.0
5	-.3922893		5	.0206648
6	-.1389568		6	.0206648
7	+.1389568		7	.0206648
8	+.3922893		8	.0206648
9	-.5547808		9	0.0
10	-.5340966		10	.0106163
11	-.3922893		11	.0180243
12	-.1389568		12	.0106163
13	+.1389568		13	.0106163
14	+.3922893		14	.0810243

TABLE 2-2 (Cont'd)

S_n	Direction Cosines (μ_m)		Weights (W_m)
15	+.5370966	15	.0106163
16	-.6651042	16	0.0
17	-.6504264	17	.0128104
18	-.5370966	18	.0072294
19	-.3922893	19	.0072294
20	-.1389568	20	.0128104
21	+.1389568	21	.0128104
22	+.3922893	22	.0072294
23	+.5370966	23	.0072294
24	+.6504264	24	.0128104
25	-.7595693	25	0.0
26	-.7467506	26	.0128104
27	-.6504264	27	.0172479
28	-.5370966	28	.0042590
29	-.3922893	29	.0172479
30	-.1389568	30	.0128104
31	+.1389568	31	.0128104
32	+.3922893	32	.0172479
33	+.5370966	33	.0042590
34	+.6504264	34	.0172479
35	+.7467506	35	.0128104
36	-.8435208	36	0.0
37	-.8319966	37	.0106163
38	-.7467506	38	.0072294
39	-.6504264	39	.0042590
40	-.5370966	40	.0042590
41	-.3922893	41	.0072294
42	-.1389568	42	.0106163
43	+.1389568	43	.0106163
44	+.3922893	44	.0072294
45	+.5370966	45	.0042590
46	+.6504264	46	.0042590
47	+.7467506	47	.0072294
48	+.8319966	48	.0106163
49	-.9198419	49	0.0
50	-.9092855	50	.0206648
51	-.8319966	51	.0180243
52	-.7467506	52	.0072294
53	-.6504264	53	.0172479
54	-.5370966	54	.0072294
55	-.3922893	55	.0180243
56	-.1389568	56	.0206648
57	+.1389568	57	.0206648
58	+.3922893	58	.0180243
59	+.5370966	59	.0072294

TABLE 2-2 (Cont'd)

S_n	Direction Cosines (μ_m)		Weights (W_m)
60	+.6504264	60	.0172479
61	+.7467506	61	.0072294
62	+.8319966	62	.0180243
63	+.9092855	63	.0206648
64	-.9902984	64	0.0
65	-.9805009	65	.0244936
66	-.9092855	66	.0206648
67	-.8319966	67	.0106163
68	-.7467506	68	.0128104
69	-.6504264	69	.0128104
70	-.5370966	70	.0106163
71	-.3922893	71	.0206648
72	-.1389568	72	.0244936
73	+.1389568	73	.0244936
74	+.3922893	74	.0206648
75	+.5370966	75	.0106163
76	+.6504264	76	.0128104
77	+.7467506	77	.0128104
78	+.8319966	78	.0106163
79	+.9092855	79	.0206648
80	+.9805009	80	.0244936

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

If anisotropic scattering calculations are performed in ANISN, quadrature sets that correctly integrate Legendre polynomials are required. Otherwise, for example, if the flux were constant in angle, the evaluation of the P_2 moment might give a non-zero result, and neutron balance would be affected. In addition, the isotropic component of the flux could include other contributions from higher moments. In general, for anisotropic scattering, the order of quadrature (n) should be, roughly, twice as large as the order of scattering (ℓ) and at least S_4.[4] It is recommended that for typical design and analysis calculations, the quadrature data sets presented in this report be used.

2.2.5 Mesh Spacing Requirements

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

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

Criteria 1: $$\Delta R \leq \frac{1.0 + \sum_{g \to g}^{S_o} / \sum_g^t}{4 \sum_g^t}$$

where: $\sum_g^t$ is the largest total or transport corrected group cross section in a region for any group.

$\sum_{g\to g}^{S_o}$ is the corresponding within group scattering cross section for the above selected group.

This criteria has been relaxed somewhat from the original equation[5] because of the negative flux fixup routine normally used in ANISN calculations.

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

Criteria 2: $\Delta Z \leq 2.0 / \sum_g^t$

where: $\sum_g^t$ is the largest total or transport corrected group cross section in the region for any group.

In problems where core memory storage limitations prevent adherence to the above two guidelines, an intuitive choice of mesh must be made to avoid questionable results. The following procedure should be followed:

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

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

Criteria 5: The intervals near the periphery of a reflected core in R-Z and R-θ problems should follow Criteria 1 and 2.

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

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

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

An approximation of mesh interval size in large non-central void regions (such as the void between a reactor and an external shield) may be represented by a method suggested by Putnam[6]". . . non-central voids should be handled by choosing mesh intervals in the void region as if a total cross section of $\Sigma_t = 1/\bar{r}$ existed in the region (where $\bar{r}$ is a mean radius). Where a large expanse of non-central void exists, it saves on mesh points to define several contiguous void regions with different r mesh interval sizes to permit fewer mesh intervals in the outer regions where $\bar{r}$ is larger."

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

2.3 DETAILED INPUT DATA INFORMATION

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

2.3.1 Time Limit Forced Convergence Option

It is desirable on eigenvalue calculations that require a considerable amount of computer time, to achieve a solution before the Central Processing Unit (CPU) time requested for the calculations has expired. Unfortunately, if the user underpredicts the amount of time required for an ANISN-W problem, the iteration process is terminated on the computer with no flux printout or punch, no activity printout, and no balance tables.

In the modified version of the ANISN program described in this report, this situation has been eliminated. By adding an additional floating point parameter on the title card (in columns 73 to 80 inclusive) in an (E8.5) FORTRAN format, the user specifies the maximum CPU time in seconds allowed for this problem. Obviously this number must be less than or equal to the time on the control card for successful operation of this parameter. If there is time for only one more outer iteration and the problem has not yet converged, a convergence trigger internal to the ANISN-W code is set to "converged" and two messages are printed out on the page containing iteration information: "Time Limit Approached," and "Outer Iteration Limit Reached." This option only works for more than two outer iterations and is based on the assumption that the next iteration will take less time than the present iteration took. The ANISN-W code then commences the final printout and punch output as if converged, thus allowing the user the option of restarting the problem with a flux guess, if desired.

For stacked ANISN-W cases, the same option is applicable, but two methods of application are possible. Consider three ANISN-W stacked cases that are estimated to

require a total of 1800 CPU seconds. In the first method, the user desires each of the three problems to run, but not necessarily to convergence. The user then would enter 600. 0, 1200. 0, and 1800. 0 seconds on the respective title cards and each problem would run with a complete printout. In the second method, the user desires each of the problems to run until convergence and, when the time limit is reached, the user desires to start the next day on that same problem and continue the stacked cases where he left off. The user would then enter 1800. 0, 1800. 0, and 1800. 0 seconds on the respective title cards and each problem would run until converged or until 1800. 0 seconds were used.

If the time estimate parameter on the title card is left blank, the ANISN-W code runs as before with no time check.

2. 3. 2 Description of Balance Tables

The ANISN-W program reads as input data or calculates the following quantities:

	Name	Description
(1)	FXS_g	, the fixed distributed (or shell) source as a function of energy group, g.
(2)	X_g	, the fractional fission spectrum as a function of energy group, g.
(3)	V_i	, the area or height of mesh interval, i. $(R_{i+1} - R_i)$, $\pi(R_{i+1}^2 - R_i^2)$, or $[4\pi / 3](R_{i+1}^3 - R_i^3)$, for slab, cylinder, or sphere, respectively.
(4)	PHI_i	, the scalar flux as a function of mesh interval, i.
(5)	DB^2	, absorption due to transverse leakage.
(6)	a/VE_g	, absorption due to a/V.
(7)	$XND_{m,\bar{i}}$	, angular flux as a function of space angle, m, and mesh line, $\bar{i}$.
(8)	ω_m	, angular quadrature weights as a function of space angle, m.
(9)	μ_m	, angular quadrature cosines as a function space angle, m.

(10) AA_i , area factor, 1, R_i, $2\pi R_i$ for slab, cylinder, or sphere, respectively.

(11) FD_i , the fission density as a function of mesh interval, i.

(12) $E1_g$, $(FXS_g + FIS_g + SNN_g)$ (Defined below)

(13) $E2_g$, $(OTS_g + APS_g + XLK_g)$ (Defined below)

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

Fixed Source

FXS_g = $\sum_i FXS_g \times V_i$

Fission Source

FIS_g = $\sum_i \left[X_g \times FD_i \times V_i\right] / \sum_i FRT_g$

In Scatter

SNN_g = $\sum_i \left[\Sigma^{g}_{g-g'} \times PHI_i \times V_i \right]$ for $g \neq g'$

Self Scatter

SFS_g = $\sum_i \left[\Sigma^{g}_{g-g'} \times PHI_i \times V_i \right]$ for $g = g'$

Out Scatter

OTS_g = $\sum_i \left[\Sigma^{g}_{t} + (DB^2) + a/VE_g \right] \times PHI_i \times V_i - APS_g - SFS_g$

Absorption

APS_g = $\sum_i \left[\Sigma^{g}_{a} + (DB^2) + a/VE_g \right] \times PHI_i \times V_i$

Net Leakage

XLK_g = $RLK_g - XLL_g$

Balance

XBB_g = $1 + ((E1_g - E2_g)/(E1_g + E2_g))$

Right Boundary Flux

$RXN_g = \sum_m XND_m^r \times \omega_m$ for region, r

Right Boundary J^+

$RFL_g = \sum_m XND_m^r \times \omega_m \times \mu_m$ for $\mu_m > 0$, for region, r

Right Boundary J

$RCT_g = \sum_m XND_m^r \times \omega_m \times \mu_m$ for all μ_m, for region, r

Right Leakage

$RLK_g = RCT_g \times AA_i$

Left Leakage

$XLL_g = AA_i \times \sum_m XND_m^r \times \omega_m \times \mu_m$ for all μ_m, for region, r

Fission Rate

$FRT_g = \sum_i PHI_i \times \nu\Sigma_f \times V_i$

Total Flux

$TXN_g = \sum_i PHI_i \times V_i$

Density

$DEN_g = TXN_g / VE_g$

The ANISN-W program prints the above 16 quantities by group and by zone as well as the sum over all groups by zone, and the sum by group over all zones. In addition, RLK_g, XLL_g, and TXN_g are punched out, if desired.

2.3.3 Space Point Renormalization Scaling[7]

The rate of convergence of the inner iterations of a discrete ordinates transport code is primarily dependent on two factors: the size of the non-source regions and the

dominance ratio of the respective energy group. A non-source region is one containing no external sources and no fixed source. It can be showr that the flux converges in a few iterations in or near source regions but, depending on the dominance ratio, several hundred inner iterations may be required to converge the flux many mean free paths from the source. The dominance ratio can be defined as the ratio of the number of particles that collide on the n'th iteration to the number that collide on the (n-1)'th iteration. Obviously these two effects are related and indicate the desirability of a space-dependent acceleration method.

In the conventional discrete ordinates inner iteration calculation, the flux matrix is scaled by a single factor which effectively removes the within-group scatter error. The balance equation which is applicable to any group after n iterations can be expressed as:

$$L\emptyset^n + \sum_s \emptyset^n = S + \sum_s \emptyset^{n-1} \qquad (1)$$

where $L\emptyset$ is the loss rate, $\sum_s \emptyset$ is the within-group scatter rate, and S includes all sources external to the group. A single scale factor f is desired so that the following equation is satisfied:

$$f\,(L\emptyset^n) = S \qquad (2)$$

From Equations (1) and (2):

$$f = S/\left[\, S + \sum_s (\emptyset^{n-1} - \emptyset^n)\right] \qquad (3)$$

A more general approach is to seek a separate scale factor for each space interval. Restricting Equation (1) to the i'th interval yields the following:

$$L\emptyset_i^n + \sum_s \emptyset_i^n = S_i + LL_i + LR_i + \sum_s \emptyset_i^{n-1} \qquad (4)$$

Where LL is the leakage into interval i across the left boundary, and LR is leakage into interval i across the right boundary. Given a scale factor for each interval, the desired balance equation becomes:

$$f_i\,(L\emptyset_i^n) = S_i + f_{i-1}\,LL_i + f_{i+1}\,LR_i \qquad (5)$$

Combining Equations (4) and (5) yields:

$$-f_{i-1}\,LL_i + \left[\, S_i + LL_i + LR_i + \sum_s \phi_i^{n-1} - \sum_s \phi_i^{n} \,\right] f_i - f_{i+1}\,LR_i = S_i \qquad (6)$$

Writing Equation (6) for each interval and applying appropriate boundary conditions leads to a tri-diagonal matrix* equation which is readily solved for all f_i. In the modified version of ANISN described in this report, the flux in each interval on every third inner iteration is scaled by the corresponding space point normalization scale factor, f_i, obtained by the solution of the tri-diagonal matrix defined above.

2.3.4 Limitations

In performing ANISN-W calculations, two types of limitations can be encountered; the first limitation occurs when the application of one-dimensional transport theory to a calculation is inadequate or inapplicable, and the second limitation occurs due to insufficient core data storage space.

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

> ". . . . The linear Boltzmann equation for transport theory is not derived from first principles of physics. On the contrary, it is stated as a flow balance for a differential phase space cell, treating in a phenomenological manner the events causing an increase or decrease in the number of particles contained in the cell. The discrete ordinates difference equation may be stated in an equivalent manner for a finite or difference phase space cell, and this is the manner in which the equation is presented in most references. In fact, for some time it was questioned as to whether the discrete ordinates equations would in general approach the analytic form of the Boltzmann equation as the finite difference phase space cell approached differential size. . . .
>
> ". . . . In order to discuss the application of the discrete ordinates method to deep penetration problems, the basic approximations will be reviewed.

---

* i.e., $a_{ij} = 0, \left| j-1 \right| > 1$

The definition of a finite phase space mesh and the subsequent approximations involved in integrating the differential equation over a mesh cell constitute the major approximation. The space, angle, and energy mesh should be sufficiently fine to give the desired resolution in the angle dependent spectra and to provide sufficient accuracy for the mean value approximation as used in the convection terms of the transport equation. Although it is relatively easy to choose a mesh for a desired resolution it is not currently possible to determine the accuracy of the difference equations for a specific mesh for nonanalytic problems. Since the mesh is adjustable, current practice is to first select a reasonable mesh based on experience and then make a few adjustments to determine the effect of a finer mesh on the desired answer. For deep penetration problems, it is particularly true that one cannot use a crude mesh in energy, space, or angle. For example, extreme penetrations in one-dimensional geometry have occasionally required 400 space intervals, 100 energy groups, and 32 angle intervals. The typical one-dimensional shielding problem uses 100 - 200 space points, 30 to 100 energy groups, and 16 to 64 angles.

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

". . . .The remaining major approximation in the method is the truncated polynomial expansion of the differential scattering cross sections. There are really two types of anisotropic scattering, first the heavy nuclide elastic scattering of neutrons which at high energies is extremely anisotropic, but the angle energy correlation is unimportant; second is the elastic scattering of neutrons by hydrogen or the Compton scattering of gammas which has an important angle energy correlation which becomes an angle group correlation. The method used for anisotropic scattering in the discrete ordinates equations as developed in Equations (27) through (32) appears to work very well for both types of scattering. Experience to date has shown that low order approximations such as P_2 and P_3 are adequate for most practical problems, and rather severe problems have been adequately resolved with P_5 or P_6.

". . . .There is an important difference between the anisotropic scattering technique used in the discrete ordinates method and the techniques based on Legendre polynomials which are frequently used with Monte Carlo or moments methods. In the discrete ordinates method, the energy and angle effects of

scattering are described independently. That is to say that the scattering law is not included in the discrete ordinates method but is implied in the cross section matrices. As a result of this, the energy transfer cross sections may be conveniently based on much more accurate information than the angular information. For example, the multigroup transfer coefficients (Equation 31) may be derived from data including a P_{15} expansion of the differential scattering cross section in the center of mass system, while the final results will be used for a P3 expansion in the laboratory system. Thus, a P3 ANISN calculation may be superior to a Monte Carlo calculation, using a P3 representation of the same basic data. The evidence to date indicates that a good description of the energy transfer effect requires a higher order approximation than is necessary to adequately describe the angle effect. . . .

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

The second limitation of insufficient core data storage space results from attempting to run too large a problem for the amount of data storage specified on the LIM1 card. On the MSFC UNIVAC-1108 Computer with the EXEC-8 Monitor System, the maximum value of LIM1, or the amount of available problem data storage, is approximately $49,000_{10}$ when used with $65K_{10}$ core locations. Because the ANISN-W program is written in variable dimension, on any given data array no size restriction is imposed; a size restriction is only imposed on the length of the sum of all data arrays. For this reason changing the code to use more core storage for data should it become available at MSFC, can be easily accomplished by changing only one FORTRAN card in the main program of the ANISN-W code.

When reading in a large number of cross sections (>45000 numbers) insufficient space is available for a complete balance table calculation. If balance tables are desired, cross sections may be stored on tape by setting IDAT1 = 1 or 2.

If an unusually large number of cross sections are required in a calculation, and the calculation does not fit on the computer, then the SATURN program must be used to prepare a group independent cross section tape. This program prepares the cross sections in the form that ANISN-W internally prepares normally input cross sections so that, at execution, no cross section preparation is required with this special tape. The user can then successfully perform the calculation by setting IDAT1 = 1 or 2.

2.3.5 Boundary Conditions

The ANISN-W code has provisions for specifying the boundary conditions at each of the two external surfaces of a problem. These boundaries are labeled "left" and "right" where the "right" boundary has the greater coordinate dimension. The user has a choice of the following five boundary conditions:

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

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

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

4) White - the angular flux, $\emptyset(r,E,\vec{\Omega}\ )$, leaving the specified boundary is integrated over the angular variable, $\vec{\Omega}$. This flux is then returned

isotropically at the same boundary as a function of energy and angle. The white boundary condition is recommended for the outer boundary of spherical and cylindrical cells.

5) Albedo - the angular flux, $\emptyset(r, E, \vec{\Omega})$, leaving the specified boundary is integrated over the angular variable, $\vec{\Omega}$. The flux is then returned isotropically at the same boundary as a function of energy and angle, proportioned by the energy-dependent input albedo (25* or 26*). If the albedo (or fraction of returning particles) is not specified, an albedo of 1.0 is assumed.

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

1) A vacuum boundary condition at the left boundary is impossible for cylindrical or spherical geometries.
2) A periodic boundary condition for one boundary is an impossible specification. Both boundaries must be specified as periodic.
3) A periodic boundary condition is impossible for cylindrical and spherical geometries.
4) A reflective right boundary condition is impossible for cylindrical and spherical geometries.
5) An input albedo boundary specification greater than 1.0 generates particles.

2.3.6 Cross Section Mixing Table

The cross section mixing table is used to combine elements into macroscopic mixtures and to specify the method of the concentration search. Experience will reveal that only the imagination limits its flexibility. The user must be careful to follow the

mixture corresponding to the P_ℓ cross section data for $\ell = 0$ by the data for $\ell = 1$, $\ell = 2$, etc., in the 10$ array for a given calculation. The following table illustrates the three types of operations performed by the mixing table:

	10$	11$	12*
1.	M	0	X
2.	M	N	X
3.	M	M	0.0

1. Multiply all cross sections in material M by X,
2. Multiply all cross sections in material N by X and add to corresponding cross sections in material M, and
3. Multiply all cross sections in material M by EV, the eigenvalue (concentration search).

2.3.7 Cross Sections

ANISN-W expects a table of cross sections for each group, g, of each material in the following format:

Position	Cross Section Type	
1	$\sigma_{activity}$	Optional
.	$\sigma_{activity}$	
.	$\sigma_{activity}$	
.	$\sigma_{activity}$	
IHT-2	$\sigma_{absorption}$	
IHT-1	$\nu\sigma_{fission}$	
IHT	σ_{total} (or $\sigma_{transport}$)	
IHT+1	$\sigma_{g} + NUS^{*} \rightarrow g$	upscatter
.	.	
.	.	
.	.	
IHS-1	$\sigma_{g+1 \rightarrow g}$	

Position	Cross Section Type	
IHS	$\sigma_{g \rightarrow g}$	
IHS+1	$\sigma_{g-1 \rightarrow g}$	
.	.	downscatter
.	.	
.	.	
IHM	$\sigma_{g-NDS^* \rightarrow g}$	

Thus the parameters IHT, IHS, and IHM completely describe the format of the cross sections. If no activity cross sections appear, IHT=3. If no upscatter is present, IHS=IHT+1. If no downscatter is present, IHM=IHS (i. e. , a one-group problem). If upscatter exists, ANISN-W will compute a total upscatter cross section for each group of each material and place that cross section in position IHM+1. This upscatter cross section is printed output. The activity cross sections are used only for activities (22$, 23$) and need not appear in the region specification (9$). Cross sections may be input from cards and/or from tape.

The P_ℓ cross section tables must correspond in format to the P_0 tables even though the transfer coefficients including the within-group scatter are the only non-zero numbers. Note: The P_ℓ cross sections must contain a $(2\ell + 1)$ term. Previous S_n codes supply this term internally, (e.g., DTF-II and DTK multiplied the P_1 cross sections by 3. 0). This factor may be included externally or internally via the mixing table. The Master Library Tapes supplied MSFC contain the $(2\ell + 1)$ term required by ANISN-W.

The SATURN, APPROPOS, and GAMLEG-W codes are used to generate a group dependent, binary cross section tape for input to ANISN-W. The logical record structure on the tape is as follows:

Logical record 1 - Total number of sets of data on the tape and a six character tape identification word.

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* NUS is the number of upscatter positions in the cross section table, and NDS is the corresponding number of downscatter positions in the cross section table.

Logical record 2 - 4 integer data words and an 8 word alphanumeric title (number of groups (IGM), cross section table length (IHM), position of sigma total (IHT), cross section set identification number, and the title).

Logical record 3 - Cross section data (IHM x IGM values)

Logical record 4, 6, - Same as 2.

Logical record 5, 7: - Same as 3.

A special purpose program is available, called SATURN, which will prepare a group independent cross section tape for input to ANISN-W. This tape is required if the complete input cross section matrix ((MCR + MTP) x IGM x IHM) is larger than the number of data locations available. The user sets ID2=1 and IDAT1 > 0 when this tape is used.

2.3.8 Material Numbers

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

When the order of scatter for any zone (19$) is greater than zero, ANISN expects the P_1 cross sections to be material M + 1, the P_2 cross sections to be M + 2, etc., where M is the P_0 material number specified in the 9$ array. The order of scatter by zone is then specified by a positive integer in the 19$ array. If a 9$ entry is negative, no transverse leakage correction is made for that zone.

2.3.9 Activities

Activities may be computed by zone and interval as specified in ID3 and ID4. This option provides a rapid and economical way to obtain data such as reaction rates,

dose rates, capture or other desired response rates. The zone activity is a total reaction rate and the interval activity is per unit volume. The following table illustrates the use of activity specifications.

	22$	23$
1.	1	3
2.	-5	1
3.	7	-1
4.	-3	-1

1. Compute activity for material 1, cross section position 3 in the intervals and/or zones in which material 1 appears.

2. Compute activity for material 5, cross section position 1 in all intervals and/or zones, because of the negative entry in the 22$ array.

3. Compute activity for material 7, position 1 in appropriate intervals and/or zones and multiply interval activities by 1.0, $2\pi r$, or $4\pi r^2$ for slab, cylinder, or sphere, respectively, because of the negative entry in the 23$ array.

4. Compute activity for material 3, position 1 in all intervals and/or zones and multiply interval activities by geometry factor.

If the position of IHT is zero, the code will sum across the diagonal of the scattering matrix and place a number in the position IHT-2. This calculation is necessary to compute the correct transverse leakage for P_ℓ calculations. If an activity appears in position IHT-2 and is to be computed, the user must insure that the position of IHT is non-zero for all groups for that material.

If the activity cross sections are to be group collapsed properly, they must appear in table positions $\leq$ IHT. If group collapsing of the cross sections is not anticipated, activity cross sections can be entered in any table position.

2.3.10 Cross Section Weighting

When microscopic weighted cross sections are requested (ICON = 1 or 3), a set of cross sections is produced for each component of each material in each zone. When macroscopic cross sections are requested (ICON = 2 or 3), a set of cross sections is produced for each material in each zone. The cross sections are weighted by the flux or current in the zone in which the material appears. Since the mixing table is used to determine the components of a material, MS should not be zero when ICON = 1 or 3. The weighted cross sections are placed on tape 4 for use in subsequent ANISN-W or DOT-IIW calculations. These weighted cross sections may also be punched on cards, if desired.

If the cross section structure specified for the weighted cross sections will not accommodate the complete multigroup scattering matrix, the "extra" transfer coefficients are placed such that they transfer as far down (or up) as possible.

If complete removal of the upscatter is desired, IHSF should be minus. (IHSF) should be the position of the self-scatter cross section before the upscatter is removed. IMHF should be the final table length. After the upscatter is removed, IHSF will be IHTF + 1. The upscatter is removed by subtracting the reaction rate due to $\sigma_{i \rightarrow i}$ from the reaction rate due to $\sigma_{i \leftarrow j}$ where $j > i$. Thus, the net transfer rate between groups j and i is preserved.

The parameter IGBF in the 27$ array defines the number of neutron and photon groups in a simultaneous calculation. For other calculations, IGBF is simply the number of energy groups in the problem.

2.3.11 Searches

When the absolute value of the difference between two successive lambdas (λ_1) is less than EQL, the eigenvalue, EV, is changed. The first EV change is the result of

adding or subtracting the eigenvalue modifier, EVM. The second EV change is the result of a linear extrapolation. To prevent large changes early in the calculation, the absolute value of the difference between 1.0 and λ_1 is not allowed to exceed XLAH. To prevent oscillations when using the linear search, the extrapolation is limited by XNPM. The third EV change is the result of the quadratic search. The quadratic search is used until the absolute value of $1.0 - \lambda_1$ is less than EQL. At this point, the linear search is used to complete the problem. XLAH is normally 0.05 and XNPM is normally 0.75. EQL should be the larger of 0.001 and three times EPS. In cases where EPS is quite small; EQL may be less.

If IPVT = 1, ANISN-W will search for the parameter which results in an eigenvalue of PV. If IPVT = 2, ANISN-W will search for a parameter which results in an eigenvalue of 1.0 when α = PV. If IPVT = 0, ANISN-W will search for an eigenvalue of 1.0 with α = 0.0.

The following table indicates suggested initial values of EV and EVM:

IEVT	EV	EVM
0	0.0	0.0
1	0.0	0.0
2	0.0	0.0
3	1.0	-0.1
4	0.0	-0.1
5	outer radius	-(10% of outer radius)
6	1.0	-0.1

When IEVT = 0, there is no eigenvalue (EV).

When IEVT = 1, the multiplication factor (k) is the eigenvalue.

When IEVT = 2, α is the eigenvalue.

When IEVT = 3, the eigenvalue is defined by its use in the mixing table.

When IEVT = 4, the eigenvalue is used as follows:

$$\Delta R_I = \Delta R_I^{\circ} (1.0 + EV \times RM_Z)$$

Where ΔR_I° is the initial ΔR

RM_Z is the radius modifier (20*)

When IEVT = 5, the outer radius is the eigenvalue.+

When IEVT = 6, $EV = DY/DY^{\circ} = DZ/DZ^{\circ}$

Where DY° and DZ° are input.

2.3.12 Multiple Cases

The ANISN-W data arrays are stored in core in the order in which they are numbered. For example, the fission density (2*) follows the fission spectrum (1*). No data is destroyed between cases. If problem dimensions change, the repositioned arrays are simply read into core over the previous data. The result is that all arrays following and including the first array to be repositioned must be respecified. The 15$ and 16* parameter arrays are exceptions to the above discussion and are never destroyed. Multiple cases in which IDAT1 changes will not retain data properly. If IDAT1 = 1, multiple cases will retain data properly only if ID2 = 2 in all cases following case 1. If IDAT1 = 2, multiple cases will retain data properly only if ID2 = 2 and IFN = 2 in all cases following case 1. If there is upscatter, multiple cases will retain data properly only if ID2 = 2 or if the complete cross section matrix is read in all cases.

In cases where the data in a particular section remains the same in multiple cases, one may enter a card containing only a T in any of the six appropriate columns for that section of data (e.g., the 15$, 16* section).

If any case is preceded by an adjoint solution, the following arrays must be respecified if they are required for the next case: 14*, 17*, 18*, 3*, 1*, 5*, 24$, 25*, 26*.

+ In outer radius search calculations, the radii or zones are adjusted.

If multiple cases are completely independent of each other (i.e., all data are specified in each case) the data of each independent case may be terminated with a T in the third column of two successive fields on the same card. This "double T" can be used instead of the normal single T, if desired. If ANISN-W terminates a case abnormally, the code will search through the dependent cases for the "double T" and attempt to execute the independent problem following.

2.3.13 Other Input Data Information

Starting Guess - IFN, 2*, 3*, 3U

If IFN is specified as zero, ANISN-W will execute a diffusion solution for the first outer iteration. Since this is undesirable for fixed source calculations where one normally desires a zero flux guess, one may set IFN = 1 and enter no guess. Simply enter a card with a T in column three for that section of data. If fissile material is present in the calculation, the flux guess in the intervals spanning that material must be non-zero. The best flux guess is the punched converged flux solution from a similar problem, with the same number of groups and mesh intervals. It helps to enter a zero flux guess in non-fissile materials if no "good" flux guess is available, but an entry of F1.0 will work also, although longer time will be required to achieve convergence.

Convergence - EPS, XLAL, RYF

The inner or flux iterations are considered converged when both the integral self-scatter error and the integral removal error are less than EPG or when the maximum flux deviation is less than EPS. EPG is related to EPS by a normalization factor, the total source divided by IGM. Since the integral tests are sometimes easily satisfied, a point flux convergence should be specified. A point flux convergence criteria of XLAL = 2*EPS is recommended for typical design calculations. If XLAL is greater than zero, the inner iterations are not considered converged until the maximum pointwise flux deviation is less than XLAL.

The outer or power iteration is considered converged when the total source ratio between successive iterations differs from 1.0 by less than EPS, the total scatter ratio differs from 1.0 by less than EPS/RYF and the upscatter ratio differs from 1.0 by less than EPS/RYF.

Transverse Leakage Correction - BF, DY, DZ

ANISN-W computes a correction factor of the DB^2 form for finite transverse dimensions. The correction is added to Σ_t and Σ_{gg} and is applicable for all orders of P_ℓ scattering in the WANL version of the code.

Distributed Source - IQM, 17*

The distributed source is entered by group and interval as follows: Group 1, interval 1 through IM; group 2, etc.

If IQM = 2, the distributed source is entered from tape 9. This tape must have IGM records containing IM pieces of data. Entered in the 17$ array is the range, k^{th} through m^{th} interval, containing the desired distributed source; where $k < m \leq IM$.

Shell Source - IPM, IPP, 18*

If IPM = 1, the shell source is entered by group, and angle for interval IPP as follows: group 1, angle 1 through angle MM; group 2, etc.

If IPM = IM, the shell source is entered by group, interval and angle as follows: group 1; interval 1, angle 1 through angle MM; interval 2, etc.

If IPM = -1, the shell source from tape 9 is entered by group, and angle at the right boundary of mesh interval IPP.

Void Streaming Correction

Since the DB^2 term is not applicable to a void region, ANISN-W computes a simple correction which effectively removes the transverse component of each angular flux in the void region. Note that BF must be non-zero when DY and DZ are input as zero in problems containing void regions. The method was taken from Nuclear Science and Engineering, February, 1965, p. 271. This correction term is not included in the

calculation of the absorption reaction rate as are the DB^2 losses. This omission causes the neutron balance to differ from 1.0. The quantity DFM1 is the height or extent of the void region in centimeters. If DFM1 is zero, or if the total cross section is non-zero for the void regions, no correction is computed for the void regions. This correction does not properly take into account the leakage of neutrons near the ends of a void and does not properly treat voids with a low L/D ratio.

Normalization

When IEVT is greater than zero, the total fission source is normalized to XNF. When IEVT is equal to zero, the total fixed source is normalized to XNF and the fission source, if any, is unnormalized. If XNF = 0.0, no normalization is done.

Auxiliary Tape Storage - IDAT1

If IDAT1 is specified as zero, ANISN-W will use the most efficient data storage possible and consume the least amount of PP (peripheral processor) time. IDAT1 must be specified as 1 or 2 if ID2 = 1. The most efficient way to run ANISN on the UNIVAC-1108 is to specify IDAT1 = 0, if possible.

If core storage of data is not possible with IDAT1 = 0, the ANISN-W code will internally set IDAT1 = 1, and place cross sections and/or source data on tape. If core storage of remaining data is still not possible, with IDAT1= 1, the ANISN-W code will internally set IDAT1= 2, and place flux and current data on tape. If the calculation cannot be run after setting IDAT1 = 2, execution is terminated. The problem must then be reduced in complexity for the calculation to be run.

Density Factors - IDFM, 21*

All cross sections appropriate to an interval are multiplied by the density factor for that interval. Thus one may easily and efficiently describe a void or a density variation by interval.

Diffusion Theory Solution IDAT2, 24$

If IDAT2 > 0, the 24$ array must be entered. A zero in the 24$ array implies a transport solution, a 1 indicates a diffusion theory solution, and a 2 indicates an infinite homogeneous medium calculation. If convergence is not obtained after IDAT2 iterations, the problem continues using the transport solution for all groups until convergence is obtained or ICM is reached. If IFN = 0, a diffusion theory solution is used on the first outer iteration. The infinite media calculation need have only one mesh interval in the calculation.

2.4 PROBLEM SETUP INFORMATION

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

2.4.1 Tape Assignments

The ANISN-W code has been placed on the MSFC, UNIVAC-1108 computer under the EXEC8 Monitor System. Under this System, the ANISN-W code may require a maximum of seven tapes or disks. In some instances, disk devices (FASTRAND) can be substituted for scratch tapes with a corresponding increase in PPU (Peripheral Processor Unit) and elapsed time. For many problems, however, only two tapes may be required. The tape assignments are as follows:

Tape 3, Scratch, Cross Section and Source Data
Tape 4*, Scratch, Cross Section and Source Data
} Required if IDAT1= 1 or 2

Tape 5, Input Disk

Tape 6, Output Disk

Tape 7, Punch Disk

Tape 9, Distributed or Shell Source Input Tape, Required if IQM = 2 or IPM = -1

Tape 8, Scratch, Flux and Current Data
Tape 10, Scratch, Flux and Current Data
} Required if IDAT1 = 2

Tape 14, Cross Section Library of Group Independent Cross Section Input Tape, Required if MTP > 0

Tape 17, Output Flux and Selected Data Tape

To minimize the amount of PPU (Peripheral Processor Unit) and elapsed time required for ANISN-W calculations, request scratch tapes as indicated above for those

---

* Tape 4 also contains the group-collapsed, upscatter-removed, cross sections at the end of a calculation.

problems where IDAT1 is greater than zero. If scratch tapes are not specifically requested, disk devices (FASTRAND) are automatically used.

2.4.2 Running Time

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

$$\text{CPU time (seconds)} = \frac{IM*MM*TI}{S}$$

where:

IM is the number of mesh intervals in the calculation

MM is the number of space angles in the calculation

MM = ISN+1 for plane or spherical geometry

MM = (ISN*(ISN+4))/4 for cylindrical geometry

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

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

SP_0 = 2930 calculations/second

SP_1 = 2100 calculations/second

SP_3 = 1720 calculations/second

Although a finite setup time is required, (approximately 5 to 20 CPU seconds) and is not included in the above equation, the use of the above equation yields reasonably accurate time estimates.

2.4.3 Recommended Problem Debug Procedure

By setting the maximum inner and outer iteration limit, IIM and ICM to 1, a complete printout can be obtained in less than 60 CPU seconds in almost all types of calculations. This procedure is highly recommended where a complete set of input data has been assembled from scratch. If only minor changes are made to an existing working ANISN-W deck, then the above procedure is optional. All input data will be printed out and the code will perform the standard input data error checks.

2.4.4 Error Messages

The following ANISN-W code generated error messages may be encountered:

Message Code		Description or Explanation
CORE	N	insufficient storage, N = required storage
DATA	N	there are N data errors
SNCORE	N	insufficient storage to compute P_ℓ (Legendre) coefficients. N = required storage; highly unlikely
S804-1	N	$\mu(N) = 0.0$
S804-2	0	S_n weights do not sum to 1.0 or S_n constants are not symmetric about $\mu = 0$.
VELOC	N	velocity in group N is zero and IEVT = 2
SOURCE	0	IEVT = 0 and total fixed source is $\leq$ 0
S810-1	N	radius (N) ≤ 0
S810-2	N	r (N-1) $\geq$ r (N)
S810-3	N	zone N dimensions have become negative in zone width search
S822-2	0	IEVT > 0 and total fission source is ≤ 0
FGCORE	N	insufficient storage to flux weight cross sections. N = required storage

2.4.5 Sample Problem Input

A sample problem input data listing has been included in this section to illustrate the following:

1) The flexibility of the input data formats, and

2) The structure of a complete problem.

The problem is a cylindrical geometry, S_4P_0, k-calculation containing 48 mesh intervals. The printout for this sample problem is included in Section 2.5.

TABLE 2-3

SAMPLE PROBLEM CARD INPUT LISTING

```
LIM1 = 30000
SAMPLE PROBLEM  ANISN USERS MANUAL                                        200.0
15$
          1          0          0          4          2          1
          0          6         48          1         16          3
          8         17          0          2          0          2
          0          0          0          0          0         35
          0          0          0          0         50          0
          0          0          0          1          0          0
16*
        0.0        0.0      .00001        0.0     121.68        0.0
        0.0        1.0        0.0        0.5    0.00002        0.0
        0.0        0.0
  T
14U
 9.21861E-04 2.28153E-03 1.19407E-01 0.          0.          0.          TRANS  1
 0.          7.14606E-02 0.          0.          0.          0.          TRANS  2
 0.          0.          0.          0.          0.          7.93574E-04 TRANS  3
 2.01388E-03 1.32799E-01 0.          0.          0.          0.          TRANS  4
 9.65204E-02 4.34040E-02 0.          0.          0.          0.          TRANS  5
 0.          0.          0.          0.          7.66990E-04 1.80456E-03 TRANS  6
 1.73834E-01 0.          0.          0.          0.          1.11864E-01 TRANS  7
 3.42639E-02 1.66969E-03 0.          0.          0.          0.          TRANS  8
 0.          0.          0.          7.79379E-04 1.70370E-03 2.23204E-01 TRANS  9
 0.          0.          0.          0.          1.71308E-01 6.05380E-02 TRANS 10
 7.61707E-04 1.37961E-03 0.          0.          0.          0.          TRANS 11
 0.          0.          9.93020E-04 1.97451E-03 2.87069E-01 0.          TRANS 12
 0.          0.          0.          2.50442E-01 5.10071E-02 5.96055E-04 TRANS 13
 3.21474E-04 5.27629E-04 0.          0.          0.          0.          TRANS 14
 0.          1.76230E-03 3.15251E-03 3.33725E-01 0.          0.          TRANS 15
 0.          0.          3.07826E-01 3.56273E-02 9.94575E-05 6.51342E-05 TRANS 16
 3.73543E-05 4.27837E-05 0.          0.          0.          0.          TRANS 17
 3.21971E-03 5.86559E-03 3.28968E-01 0.          0.          0.          TRANS 18
 0.          2.74740E-01 2.41365E-02 4.97519E-06 6.62011E-06 2.45863E-06 TRANS 19
 7.37807E-07 7.27927E-07 0.          0.          0.          5.82220E-03 TRANS 20
 9.58427E-03 3.33953E-01 0.          0.          0.          0.          TRANS 21
 3.08272E-01 5.10077E-02 2.68257E-07 1.42733E-06 3.41873E-06 1.20652E-06 TRANS 22
 1.16894E-07 3.49314E-07 0.          0.          1.48539E-02 2.35581E-02 TRANS 23
 3.43323E-01 0.          0.          0.          0.          3.08253E-01 TRANS 24
 1.98594E-02 0.          4.18913E-09 3.77851E-08 8.76636E-08 3.20877E-08 TRANS 25
 1.32905E-09 1.13299E-09 0.          3.41378E-02 5.02830E-02 3.63939E-01 TRANS 26
 0.          0.          0.          0.          3.15758E-01 2.02265E-02 TRANS 27
 0.          0.          2.41694E-10 1.97463E-09 0.          0.          TRANS 28
 0.          0.          2.89926E-02 3.84390E-02 3.58129E-01 0.          TRANS 29
 0.          0.          0.          3.03072E-01 1.40437E-02 0.          TRANS 30
 0.          0.          5.84494E-10 0.          0.          0.          TRANS 31
 0.          3.97494E-02 8.16961E-02 3.62939E-01 4.82150E-08 1.56901E-07 TRANS 32
 2.91748E-06 5.61373E-03 3.11950E-01 2.60639E-02 0.          0.          TRANS 33
 0.          0.          0.          0.          0.          0.          TRANS 34
 1.29442E-01 2.57440E-01 4.59819E-01 0.          2.73596E-04 8.03891E-04 TRANS 35
 1.22411E-02 3.02236E-01 1.08365E-02 0.          0.          0.          TRANS 36
 0.          0.          0.          0.          0.          1.78342E-01 TRANS 37
 3.68131E-01 5.21368E-01 0.          0.          2.35507E-03 1.24798E-02 TRANS 38
 3.16719E-01 1.83695E-02 3.38390E-04 0.          0.          0.          TRANS 39
 0.          0.          0.          0.          2.84565E-01 5.87633E-01 TRANS 40
 6.43805E-01 0.          0.          0.          9.78506E-03 3.43168E-01 TRANS 41
 1.26943E-02 3.64179E-03 5.63519E-05 0.          0.          0.          TRANS 42
 0.          0.          0.          5.81692E-01 1.20147E+00 9.54332E-01 TRANS 43
```

TABLE 2-3 (CONTINUED)

```
 *.             0.             0.             0.             3.60226E-01 2.78785E-03TRANS 44
 1.36953E-03 5.15784E-04 7.87081E-06 0.             0.             0.             TRANS 45
 *.             0.                                                               TRANS 46
-4.47473E-02 0.             1.67665E-01 0.             0.             0.             TRANS  1
 0.             6.54278E-02 0.             0.             0.             0.             TRANS  2
 *.             0.             0.             0.             0.             8.24469E-03TRANS  3
 0.             1.89592E-01 0.             0.             0.             0.             TRANS  4
 1.10744E-01 7.63109E-02 0.             0.             0.             0.             TRANS  5
 0.             0.             0.             0.             4.76204E-04 0.             TRANS  6
 2.83665E-01 0.             0.             0.             0.             1.48997E-01TRANS  7
 6.47327E-02 1.79219E-02 0.             0.             0.             0.             TRANS  8
 0.             0.             0.             1.76776E-06 0.             4.03483E-01TRANS  9
 0.             0.             0.             0.             2.93929E-01 1.33847E-01TRANS 10
 2.88203E-03 4.17783E-02 0.             0.             0.             0.             TRANS 11
 0.             0.             7.09406E-06 0.             4.72689E-01 0.             TRANS 12
 0.             0.             0.             3.84532E-01 1.09552E-01 3.44187E-04TRANS 13
 1.90702E-03 8.56074E-03 0.             0.             0.             0.             TRANS 14
 0.             1.64926E-05 0.             5.96114E-01 0.             0.             TRANS 15
 0.             0.             5.29506E-01 8.81501E-02 0.             0.             TRANS 16
 1.03184E-03 2.14060E-03 0.             0.             0.             0.             TRANS 17
 1.98068E-05 0.             6.01670E-01 0.             0.             0.             TRANS 18
 0.             4.68479E-01 6.65917E-02 0.             0.             0.             TRANS 19
 4.92201E-05 2.11786E-04 0.             0.             0.             7.31374E-06TRANS 20
 0.             6.01649E-01 0.             0.             0.             0.             TRANS 21
 5.44204E-01 1.33172E-01 0.             0.             0.             0.             TRANS 22
 0.             0.             0.             0.             2.13833E-05 0.             TRANS 23
 6.01652E-01 0.             0.             0.             0.             5.39255E-01TRANS 24
 5.74378E-02 0.             0.             0.             0.             0.             TRANS 25
 0.             0.             0.             5.91814E-05 0.             6.01689E-01TRANS 26
 0.             0.             0.             0.             5.41765E-01 6.23759E-02TRANS 27
 0.             0.             0.             0.             0.             0.             TRANS 28
 0.             0.             1.49533E-04 0.             6.01781E-01 0.             TRANS 29
 0.             0.             0.             5.32967E-01 5.98651E-02 0.             TRANS 30
 0.             0.             0.             0.             0.             0.             TRANS 31
 0.             3.59328E-04 0.             6.34386E-01 8.78997E-10 8.88409E-08TRANS 32
 3.25805E-06 7.51093E-03 5.67537E-01 6.86639E-02 0.             0.             TRANS 33
 0.             0.             0.             0.             0.             0.             TRANS 34
 7.08970E-04 0.             6.37492E-01 0.             5.30749E-04 2.55719E-03TRANS 35
 3.22208E-02 5.09614E-01 6.54832E-02 0.             0.             0.             TRANS 36
 0.             0.             0.             0.             0.             1.04093E-03TRANS 37
 0.             6.42834E-01 0.             0.             2.08712E-02 3.71785E-02TRANS 38
 5.26335E-01 1.04666E-01 9.60062E-04 0.             0.             0.             TRANS 39
 0.             0.             0.             0.             1.54778E-03 0.             TRANS 40
 7.06538E-01 0.             0.             0.             2.31362E-02 6.55798E-01TRANS 41
 7.03887E-02 1.39368E-02 4.61605E-05 0.             0.             0.             TRANS 42
 0.             0.             0.             2.90080E-03 0.             7.15259E-01TRANS 43
 0.             0.             0.             0.             6.67820E-01 9.45633E-03TRANS 44
 1.28458E-02 1.05556E-03 1.91262E-07 0.             0.             0.             TRANS 45
 0.             0.                                                               TRANS 46
 T
3*
 F       1.0
 T
1*
   .22758648    .34550195    .18047802    .15218986    .07861765    .01536485
   .00026119 9R       0.0
4*
         0.0          4.0          7.0         10.0         13.0         16.0
```

TABLE 2-3 (CONTINUED)

```
          18.0          20.0          21.5          22.5          23.5          24.25
          25.0          25.5          26.0          26.5          27.0          27.5
          28.0          28.5          29.0          29.5          30.0          30.4
          30.7          31.0          31.3          31.6          31.9          32.2
          32.6          33.0          33.5          34.0          34.5          35.0
          35.5          36.0          36.5          37.0         37.75          38.5
         39.25          40.0         40.75         41.50         42.25          43.0
          43.7
 5*
16R        1.0
 6*
   0.0              .1666667      .1666667      .1666667      .1666667      0.0
    .1666666        .1666666
 7*
   -.9367418      -.8688903      -.3500212       .3500212      .8688903     -.4950046
   -.3500212       .3500212
 8$
10R          110R          2 6R          3 7R          4 5R          510R          6
 9$
 3R          1 3R          2
  T
```

2.5 DESCRIPTION OF OUTPUT

2.5.1 Printed Output

The printout from the sample problem input data presented in Section 2.4.5 is shown in Table 2-4. The first output section printed by the ANISN-W code is a brief edit of the input data consisting of the array identification and the number of entries found in that array. If the number of entries is incorrect, the entire array is printed. T's are printed when encountered. Several self-explanatory error messages may be printed in this section. If any data errors are found, the problem is terminated after this section is printed.

The next section is a list of the 15$ and 16* array with a brief description. The following page lists the zone numbers by interval (8$), the radii (4*), the areas and volumes (computed), the fission density guess (2*), and the density factors (21*), if any. The next page contains the fission spectrum (1*), velocities (5*), right boundary albedo (25*), left boundary albedo (26*), diffusion calculation markers (24$), material numbers by zone (9$), order of scattering by zone (19$), and the radius modifiers (20*) used in zone width searches. Note that the right albedo, left albedo and diffusion markers are printed only when they are used.

The following section contains the cross section mixing table (10$, 11$, 12*) and the quadrature coefficients including the direction cosines (7*), the weights (6*), the reflected direction indices (computed) and the product of the cosines and weights. If ISCT is greater than one, the Legendre coefficients used in the anisotropic scattering source are printed.

Next, the cross sections for MT materials, as read in and computed or modified via the mixing table, are printed. This section of printing may be omitted by specifying IPRT = 1.

The iteration monitor follows and includes the outer iteration counter, the inner iteration counter, balance (gains/losses), upscatter ratio, eigenvalue, lambda1 (source ratio), and lambda2 (scatter ratio). Immediately preceding the final iteration monitor, the

number of inner iterations, the maximum flux deviation and its location for each group are printed.

Following the iteration monitor, the zone numbers, radii, interval midpoints, areas, volumes, and computed fision density are printed. The fission density units are source particles $-cm^{-3} - sec^{-1}$.

If ID3 is greater than zero, activities comprise the next section of output. The activity number, material number (22$) and position (23$) are printed. The activities by zone are printed in units of reactions per second. If ID4 is not zero, the interval activities (reactions $-cm^{-3} - sec^{-1}$) are printed.

The total flux (neutrons - (or gamma $cm^{-2} -sec^{-1}$) by group and interval midpoint follows. If IEVT is zero, the normalized fixed source is printed next. The distributed source, specified by group and interval midpoint, has units of particles $-cm^{-3} -sec^{-1}$. The shell source units are particles $-cm^{-2} -sec^{-1} -unit\ weight^{-1}$.

If ID1 is 1 or 3, the angular flux (particles $-cm^{-2} -sec^{-1}$ unit $weight^{-1}$) is printed for each group, angle, and interval boundary. Note that the shell source, if any, is not included in the angular flux. To convert to flux per steradian, one must divide by 4π.

Summary tables are printed for each zone and the entire system. All reaction rates have units of reactions per second. Balance is computed as the ratio of sources to losses. The right boundary flux is the scalar flux (particles $-cm^{2} -sec^{-1}$) at the right boundary of the zone or system. The total flux is the sum over the appropriate intervals of the product of the scalar flux and the interval volume. Density is the total flux divided by the group velocity. The material buckling is then printed.

If IFG is not zero, cross section weighting data follow. The parameters (27$) are printed with a brief explanation. An interpretation of the 28$ array which indicates the few group structure is printed. If the multigroup structure is unaltered, a message to

that effect is printed. Next, a table of materials to be weighted is printed. The weighted cross sections follow. If cell weighting is specified, a message is printed indicating that the cell weighting has been accomplished. Note that the cell weighted cross sections have been multiplied by a volume integrated flux ratio. To produce a set of homogenized cell cross sections, one should add all P(0) materials together, all P(1) materials, etc. The final table consists of the few group integrated flux, average flux, the zone to cell ratio of the two, and the volume fraction of each zone. All values listed for zone IZM + 1 refer to the complete cell or system.

2.5.2 Tape Output

The ANISN-W code places on tape 17 specific parameters and arrays useful in the automated linkage of ANISN-W with other computer codes. For example, the scalar fluxes are used by the NAGS code to compute fixed source distributions or energy deposition. The same tape is also used in the APPROPOS code as spectral weighting data. Table 2-5 presents a description of the contents of tape 17.

The processed cross sections obtained at user option (i.e., IFG > 0) are placed on tape 4 at the conclusion of an ANISN-W calculation. This cross section tape is in a compatible format for use in subsequent ANISN-W or DOT-IIW calculations. If both macroscopic and microscopic weightings are specified (ICON=3), then the macroscopic data by region precede the microscopic data on tape 4. The data are processed and placed on tape 4 in the order given in the 9$ and 11$ arrays with zero entries excluded. Data sets on tape 4 are numbered in sequence starting at 1.

2.5.3 Punched Output

Punched card output from the ANISN-W code is determined from the value of ID1 in the 15$ data array. If ID1 is specified as 0 or 1, no punched card output is produced. If ID1 is specified as 2 or 3, the following information is punched:

1. Title card
2. 3U card
3. Scalar fluxes by interval and by group (Each group starts on a new card)
4. Four blank cards
5. Right leakage for Zone 1
6. Left leakage for Zone 1
7. Total flux for Zone 1
   (cards 5, 6, and 7 are then repeated for each zone)
8. Two blank cards
9. 2U card
10. Source neutron density by interval

Items 3, 5, 6, 7, and 10 are punched on cards in a FORTRAN (6E12.5) format. Items 2 and 3 constitute a complete flux guess (in reality, the converged flux solution), while items 9 and 10 constitute a complete source neutron (or fission density) guess for re-running the problem.

TABLE 2-4

SAMPLE PROBLEM COMPUTER PRINTOUT

```
SAMPLE PROBLEM  ANISN USERS MANUAL

                          THE TIME ESTIMATE FOR THIS PROBLEM IS    200.00 SECONDS

  15$ ARRAY      36 ENTRIES READ

  16* ARRAY      14 ENTRIES READ

   T

 5097 LOCATIONS WILL BE USED FOR THIS PROBLEM

NON-STANDARD INPUT FORMAT USED

  14U ARRAY     544 ENTRIES READ

   T

  3* ARRAY     768 ENTRIES READ

   T

  1* ARRAY      16 ENTRIES READ

  4* ARRAY      49 ENTRIES READ

  5* ARRAY      16 ENTRIES READ

  6* ARRAY       8 ENTRIES READ

  7* ARRAY       8 ENTRIES READ

  8$ ARRAY      48 ENTRIES READ

  9$ ARRAY       6 ENTRIES READ

   T
```

TABLE 2-4 (CONTINUED)

SAMPLE PROBLEM ANISN USERS MANUAL

ID	PROBLEM ID NO.	1	ITH	0/1 = REG./ADJ.	0
ISCT	ORDER OF SCATTERING	0	ISN	QUADRATURE ORDER	4
IGE	1/2/3 = PLA/CYL/SPH	2	IBL	0/1/2/3 = NO REFL/REFL/PER/WHITE	1
IBR	RT. B.C. SAME AS LEFT B.C.•IBL	0	IZM	NO. OF ZONES	6
IM	NO. OF INTERVALS	48	IEVT	0/1/2/3/4/5/6=Q/K/ALPHA/C/Z/R/H	1
IGM	NO. OF GROUPS	16	IHT	POS. OF SIGMA T	3
IHS	POS. OF SIGMA GG	8	IHM	TABLE LENGTH	17
MS	MIXING TABLE LENGTH	0	MCR	NO. MATLS. FROM CARDS	2
MTP	NO. MATLS. FROM LIB TAPE	0	MT	NO. OF MATLS.	2
IDFM	0/1=NONE/DENSITY FACTORS(21*)	0	IPVT	0/1/2=NONE/K/ALPHA	0
IQM	0/1=NONE/DIST. SOURCE	0	IPM	0/1/IM=NONE/S(MM,IPP)/S(MM,IM)	0
IPP	INTERVAL OF SHELL SOURCE	0	IIM	INNER ITER. MAX.	35
ID1	0/1/2/3=NO/PRNT NO/PNCH N/BOTH	0	ID2	0/1/2=NO/X-SEC TAPE/PREV	0
ID3	0/N=NO/N ACT. BY ZONE	0	ID4	0/1=NO/N ACT. BY INT.	0
ICM	OUTER ITER. MAX.	50	IDAT1	0/1/2=NO/MIN/MAX TAPE	0
IDAT2	0/1=NO/DIFFUSION(24S)	0	IFG	0/1=NO/FEW GRP.	0
IFLU	0/1/2=BOTH/LINEAR/STEP	0	IFN	0/1/2=INPUT 2*/3*/PREV. CASE	1
IPRT	0/1 = PRINT X-SEC/DO NOT	0	IXTR	0/1=CALC/READ P-L CONSTANTS	0

EV	EIGENVALUE GUESS	0.	EVM	EIGENVALUE MODIFIER	0.
EPS	PRECISION DESIRED	1.00000E-05	BF	BUCKLING FACTOR	1.00000E-40
DY	CYL OR PLA HEIGHT	1.21680E+02	DZ	PLANE DEPTH	0.
DFM1	HT. FOR VOID CORR.	0.	XNF	NORM. FACTOR	1.00000E+00
PV	IPVT=1/2 - K/ALPHA	0.	RYF	LAMBDA2 RELAXATION	5.00000E-01
XLAL	PT CNVRG EPS. IF .NE.0	2.00000E-05	XLAH	1-LAMBDA MAX.-SEARCH	0.
EQL	EV CHANGE EPS.-SEARCH	0.	XNPM	NEW PARAM. MOD.-SEARCH	0.

TABLE 2-4 (CONTINUED)

SAMPLE PROBLEM ANISN USERS MANUAL

INT.	ZONE NUMBER	RADIUS	AREA	VOLUME	FISS DENS	DENS FACTOR
1	1	0	0	5.02655E+01	0	
2	1	4.00000E+00	2.51327E+01	1.03673E+02	0	
3	1	7.00000E+00	4.39823E+01	1.60221E+02	0	
4	1	1.00000E+01	6.28319E+01	2.16770E+02	0	
5	1	1.30000E+01	8.16814E+01	2.73319E+02	0	
6	1	1.60000E+01	1.00531E+02	2.13628E+02	0	
7	1	1.80000E+01	1.13097E+02	2.38761E+02	0	
8	1	2.00000E+01	1.25664E+02	1.95564E+02	0	
9	1	2.15000E+01	1.35088E+02	1.38230E+02	0	
10	1	2.25000E+01	1.41372E+02	1.44513E+02	0	
11	2	2.35000E+01	1.47655E+02	1.12508E+02	0	
12	2	2.42500E+01	1.52367E+02	1.16043E+02	0	
13	2	2.50000E+01	1.57080E+02	7.93252E+01	0	
14	2	2.55000E+01	1.60221E+02	8.08960E+01	0	
15	2	2.60000E+01	1.63363E+02	8.24668E+01	0	
16	2	2.65000E+01	1.66504E+02	8.40376E+01	0	
17	2	2.70000E+01	1.69646E+02	8.56084E+01	0	
18	2	2.75000E+01	1.72788E+02	8.71792E+01	0	
19	2	2.80000E+01	1.75929E+02	8.87500E+01	0	
20	2	2.85000E+01	1.79071E+02	9.03208E+01	0	
21	3	2.90000E+01	1.82212E+02	9.18916E+01	0	
22	3	2.95000E+01	1.85354E+02	9.34624E+01	0	
23	3	3.00000E+01	1.88496E+02	7.59009E+01	0	
24	3	3.04000E+01	1.91009E+02	5.75854E+01	0	
25	3	3.07000E+01	1.92894E+02	5.81509E+01	0	
26	3	3.10000E+01	1.94779E+02	5.87164E+01	0	
27	4	3.13000E+01	1.96664E+02	5.92819E+01	0	
28	4	3.16000E+01	1.98549E+02	5.98473E+01	0	
29	4	3.19000E+01	2.00434E+02	6.04128E+01	0	
30	4	3.22000E+01	2.02319E+02	8.14301E+01	0	
31	4	3.26000E+01	2.04832E+02	8.24354E+01	0	
32	4	3.30000E+01	2.07345E+02	1.04458E+02	0	
33	4	3.35000E+01	2.10487E+02	1.06029E+02	0	
34	5	3.40000E+01	2.13628E+02	1.07600E+02	0	
35	5	3.45000E+01	2.16770E+02	1.09170E+02	0	
36	5	3.50000E+01	2.19911E+02	1.10741E+02	0	
37	5	3.55000E+01	2.23053E+02	1.12312E+02	0	
38	5	3.60000E+01	2.26195E+02	1.13883E+02	0	
39	6	3.65000E+01	2.29336E+02	1.15454E+02	0	
40	6	3.70000E+01	2.32478E+02	1.76126E+02	0	
41	6	3.77500E+01	2.37190E+02	1.79660E+02	0	
42	6	3.85000E+01	2.41903E+02	1.83194E+02	0	
43	6	3.92500E+01	2.46615E+02	1.86728E+02	0	
44	6	4.00000E+01	2.51327E+02	1.90263E+02	0	

TABLE 2-4 (CONTINUED)

45	6	4.07500E+01	2.56040E+02	1.93797E+02	0
46	6	4.15000E+01	2.60752E+02	1.97331E+02	0
47	6	4.22500E+01	2.65465E+02	2.00866E+02	0
48	6	4.30000E+01	2.70177E+02	1.90663E+02	0
49		4.37000E+01	2.74575E+02		

TABLE 2-4 (CONTINUED)

SAMPLE PROBLEM ANISN USERS MANUAL

	FISS SPEC	VELOCITY	RT ALBEDO	LFT ALBEDO	DIFF MARKER	MAT#L/ZONE	L OF P(L)	RADIUS MOD
1	2.27586E-01	1.00000E+00				1	0	0
2	3.45502E-01	1.00000E+00				1	0	0
3	1.80478E-01	1.00000E+00				1	0	0
4	1.52190E-01	1.00000E+00				2	0	0
5	7.86176E-02	1.00000E+00				2	0	0
6	1.53648E-02	1.00000E+00				2	0	0
7	2.61190E-04	1.00000E+00						
8	0	1.00000E+00						
9	0	1.00000E+00						
10	0	1.00000E+00						
11	0	1.00000E+00						
12	0	1.00000E+00						
13	0	1.00000E+00						
14	0	1.00000E+00						
15	0	1.00000E+00						
16	0	1.00000E+00						

TABLE 2-4 (CONTINUED)

SAMPLE PROBLEM ANISN USERS MANUAL

CROSS SECTION MIXING TABLE

	MIXTURE	COMPONENT	NO. DENSITY
1			
2			
3			
4			
5			
6			
7			
8			

ANGULAR QUADRATURE CONSTANTS

COSINE (MU)	WEIGHT	REFL DIRECT	WT. X COS.
-9.36742E-01	0	5	0
-8.68890E-01	1.66667E-01	5	-1.44815E-01
-3.50021E-01	1.66667E-01	4	-5.83369E-02
3.50021E-01	1.66667E-01	3	5.83369E-02
8.68890E-01	1.66667E-01	2	1.44815E-01
-4.95005E-01	0	8	0
-3.50021E-01	1.66667E-01	8	-5.83368E-02
3.50021E-01	1.66667E-01	7	5.83368E-02

TABLE 2-4 (CONTINUED)

CROSS SECTIONS

MAT NO 1

POS.	GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5	GROUP 6	GROUP 7	GROUP 8
1	9.21861E-04	7.93574E-04	7.66990E-04	7.79379E-04	9.93020E-04	1.76230E-03	3.21971E-03	5.82220E-03
2	2.28153E-03	2.01328E-03	1.80456E-03	1.70370E-03	1.97451E-03	3.15251E-03	5.86559E-03	9.58427E-03
3	1.19407E-01	1.32799E-01	1.73834E-01	2.23204E-01	2.87069E-01	3.33725E-01	3.28968E-01	3.33953E-01
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.
8	7.14606E-02	9.66204E-02	1.11864E-01	1.71308E-01	2.50442E-01	3.07826E-01	2.74740E-01	3.08272E-01
9	0.	4.34040E-02	3.42638E-02	6.05380E-02	5.10071E-02	3.56273E-02	2.41365E-02	5.10077E-02
10	0.	0.	1.66969E-03	7.61707E-04	5.96055E-04	9.94575E-05	4.97519E-06	2.68257E-07
11	0.	0.	0.	1.37961E-03	3.21474E-04	6.51342E-05	6.62011E-06	1.42733E-06
12	0.	0.	0.	0.	5.27629E-04	3.73543E-05	2.45863E-06	3.41873E-06
13	0.	0.	0.	0.	0.	4.27837E-05	7.37800E-07	1.20652E-06
14	0.	0.	0.	0.	0.	0.	7.27927E-07	1.16894E-07
15	0.	0.	0.	0.	0.	0.	0.	3.49314E-07
16	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.

POS.	GROUP 9	GROUP 10	GROUP 11	GROUP 12	GROUP 13	GROUP 14	GROUP 15	GROUP 16
1	1.48539E-02	3.41378E-02	2.89926E-02	3.97494E-02	1.29442E-01	1.78342E-01	2.84565E-01	5.81692E-01
2	2.35581E-02	5.02830E-02	3.84390E-02	8.16961E-02	2.57440E-01	3.68131E-01	5.87633E-01	1.20147E+00
3	3.43333E-01	3.63939E-01	3.58129E-01	3.62939E-01	4.59819E-01	5.21368E-01	6.43805E-01	9.54332E-01
4	0.	0.	0.	4.82150E-08	0.	0.	0.	0.
5	0.	0.	0.	1.56901E-07	2.73596E-04	0.	0.	0.
6	0.	0.	0.	2.91748E-06	8.03891E-04	2.35507E-03	0.	0.
7	0.	0.	0.	5.61373E-03	1.22411E-02	1.24798E-02	9.78506E-03	0.
8	3.08253E-01	3.15758E-01	3.03072E-01	3.11950E-01	3.02236E-01	3.16719E-01	3.43168E-01	3.60226E-01
9	1.98594E-02	2.02265E-02	1.40437E-02	2.60639E-02	1.08365E-02	1.83695E-02	1.26943E-02	2.78785E-03
10	0.	0.	0.	0.	0.	3.38390E-04	3.64179E-03	1.36953E-03
11	4.18913E-09	0.	0.	0.	0.	0.	5.63519E-05	5.15784E-04
12	3.77851E-08	2.41694E-10	0.	0.	0.	0.	0.	7.87081E-06
13	8.76636E-08	1.97463E-09	5.84494E-10	0.	0.	0.	0.	0.
14	3.20877E-08	0.	0.	0.	0.	0.	0.	0.
15	1.32905E-09	0.	0.	0.	0.	0.	0.	0.
16	1.13299E-09	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	5.61373E-03	1.22440E-02	1.32838E-02	1.28138E-02

MAT NO 2

TABLE 2-4 (CONTINUED)

POS.	GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5	GROUP 6	GROUP 7	GROUP 8
1	-4.47473E-02	8.24469E-03	4.76204E-04	1.76776E-06	7.09406E-06	1.64926E-05	1.98068E-05	7.31374E-06
2	0.	0.	0.	0.	0.	0.	0.	0.
3	1.67605E-01	1.89592E-01	2.83665E-01	4.03483E-01	4.72689E-01	5.96114E-01	6.01670E-01	6.01649E-01
4	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.
8	6.54278E-02	1.10744E-01	1.48997E-01	2.93929E-01	3.84532E-01	5.29506E-01	4.68479E-01	5.44204E-01
9	0.	7.63109E-02	6.47327E-02	1.33847E-01	1.09552E-01	8.81501E-02	6.65917E-02	1.33172E-01
10	0.	0.	1.79219E-02	2.88203E-03	3.44187E-04	0.	0.	0.
11	0.	0.	0.	4.17783E-02	1.90702E-03	0.	0.	0.
12	0.	0.	0.	0.	8.56074E-03	1.03184E-03	0.	0.
13	0.	0.	0.	0.	0.	2.14060E-03	4.92201E-05	0.
14	0.	0.	0.	0.	0.	0.	2.11786E-04	0.
15	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.

POS.	GROUP 9	GROUP 10	GROUP 11	GROUP 12	GROUP 13	GROUP 14	GROUP 15	GROUP 16
1	2.13833E-05	5.91814E-05	1.49533E-04	3.59328E-04	7.08970E-04	1.04093E-03	1.54778E-03	2.90080E-03
2	0.	0.	0.	0.	0.	0.	0.	0.
3	6.01652E-01	6.01689E-01	6.01701E-01	6.34386E-01	6.37492E-01	6.42834E-01	7.06538E-01	7.15259E-01
4	0.	0.	0.	8.78997E-10	0.	0.	0.	0.
5	0.	0.	0.	8.88409E-08	5.30749E-04	0.	0.	0.
6	0.	0.	0.	3.25805E-06	2.55719E-03	2.08712E-02	0.	0.
7	0.	0.	0.	7.51093E-03	3.22208E-02	3.71785E-02	2.31362E-02	0.
8	5.39255E-01	5.41765E-01	5.32967E-01	5.67537E-01	5.09614E-01	5.26335E-01	6.55798E-01	6.67820E-01
9	5.74378E-02	6.23759E-02	5.98651E-02	6.86639E-02	6.54832E-02	1.04666E-01	7.03887E-02	9.45633E-03
10	0.	0.	0.	0.	0.	9.60062E-04	1.39368E-02	1.28458E-02
11	0.	0.	0.	0.	0.	0.	4.61605E-05	1.05556E-03
12	0.	0.	0.	0.	0.	0.	0.	1.91262E-07
13	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	7.51093E-03	3.22241E-02	3.97358E-02	4.45381E-02

TABLE 2-4 (CONTINUED)

OUTER	INNER	NEUT BAL	UPSCATTER RATIO	EIGENVALUE	LAMBDA1	LAMBDA2	
0	0	0.	0.	0.	0.	0.	
1	302	1.0000000E+00	1.5924979E+00	1.0149277E+00	1.0149277E+00	6.3075244E+00	
2	519	1.0000000E+00	1.2830499E+00	9.9297174E-01	9.7836696E-01	1.0140903E+00	
3	705	1.0000000E+00	1.1196933E+00	9.8645949E-01	9.9344165E-01	1.0080348E+00	
4	870	1.0000000E+00	1.0564729E+00	9.8306788E-01	9.9656184E-01	1.0043718E+00	
5	1014	1.0000000E+00	1.0281241E+00	9.8123475E-01	9.9813529E-01	1.0023447E+00	
6	1141	1.0000000E+00	1.0143875E+00	9.8025138E-01	9.9899782E-01	1.0012506E+00	
7	1249	1.0000000E+00	1.0074571E+00	9.7973426E-01	9.9947247E-01	1.0006584E+00	
8	1340	1.0000000E+00	1.0039130E+00	9.7944496E-01	9.9970471E-01	1.0003527E+00	
9	1416	1.0000000E+00	1.0020562E+00	9.7928982E-01	9.9984160E-01	1.0001863E+00	
10	1482	1.0000000E+00	1.0010794E+00	9.7920357E-01	9.9991193E-01	1.0000979E+00	
11	1537	1.0000000E+00	1.0005475E+00	9.7918268E-01	9.9997867E-01	1.0000455E+00	
12	1584	1.0000000E+00	1.0002790E+00	9.7917549E-01	9.9999266E-01	1.0000239E+00	
13	1620	1.0000000E+00	1.0001428E+00	9.7917232E-01	9.9999676E-01	1.0000129E+00	
14	1645	1.0000000E+00	1.0000720E+00	9.7917101E-01	9.9999867E-01	1.0000062E+00	
15	1675	1.0000000E+00	1.0000379E+00	9.7916923E-01	9.9999818E-01	1.0000032E+00	
16	1691	1.0000000E+00	1.0000190E+00	9.7916778E-01	9.9999851E-01	1.0000017E+00	
GROUP 1	INNER ITERATIONS	1	MAX FLUX DEVIATION	5.96962E-06	AT MESH INTERVAL	1	
GROUP 2	INNER ITERATIONS	1	MAX FLUX DEVIATION	5.52907E-06	AT MESH INTERVAL	1	
GROUP 3	INNER ITERATIONS	1	MAX FLUX DEVIATION	5.91096E-06	AT MESH INTERVAL	1	
GROUP 4	INNER ITERATIONS	1	MAX FLUX DEVIATION	5.93935E-06	AT MESH INTERVAL	1	
GROUP 5	INNER ITERATIONS	1	MAX FLUX DEVIATION	7.25619E-06	AT MESH INTERVAL	1	
GROUP 6	INNER ITERATIONS	1	MAX FLUX DEVIATION	4.82134E-06	AT MESH INTERVAL	1	
GROUP 7	INNER ITERATIONS	1	MAX FLUX DEVIATION	3.25979E-06	AT MESH INTERVAL	1	
GROUP 8	INNER ITERATIONS	1	MAX FLUX DEVIATION	4.19865E-06	AT MESH INTERVAL	1	
GROUP 9	INNER ITERATIONS	1	MAX FLUX DEVIATION	3.61204E-06	AT MESH INTERVAL	1	
GROUP 10	INNER ITERATIONS	1	MAX FLUX DEVIATION	1.70272E-06	AT MESH INTERVAL	1	
GROUP 11	INNER ITERATIONS	1	MAX FLUX DEVIATION	7.85401E-07	AT MESH INTERVAL	19	
GROUP 12	INNER ITERATIONS	1	MAX FLUX DEVIATION	3.07816E-06	AT MESH INTERVAL	1	
GROUP 13	INNER ITERATIONS	1	MAX FLUX DEVIATION	5.69898E-06	AT MESH INTERVAL	1	
GROUP 14	INNER ITERATIONS	1	MAX FLUX DEVIATION	7.47759E-06	AT MESH INTERVAL	1	
GROUP 15	INNER ITERATIONS	1	MAX FLUX DEVIATION	8.34489E-06	AT MESH INTERVAL	1	
GROUP 16	INNER ITERATIONS	1	MAX FLUX DEVIATION	1.11324E-05	AT MESH INTERVAL	1	
17	1707	1.0000000E+00	1.0000099E+00	9.7916744E-01	9.9999965E-01	1.0000008E+00	FINAL MONITOR

TABLE 2-4 (CONTINUED)

SAMPLE PROBLEM ANISN USERS MANUAL

INT.	ZONE	NUMBER	RADIUS	INT. MIDPOINT	AREA	VOLUME	FISSION DENS
1	1		0.	2.00000E+00	0.	5.02655E+01	3.02845E-04
2	1		4.00000E+00	5.50000E+00	2.51327E+01	1.03673E+02	2.99822E-04
3	1		7.00000E+00	8.50000E+00	4.39823E+01	1.60221E+02	2.94941E-04
4	1		1.00000E+01	1.15000E+01	6.28319E+01	2.16770E+02	2.88511E-04
5	1		1.30000E+01	1.45000E+01	8.16814E+01	2.73319E+02	2.81213E-04
6	1		1.60000E+01	1.70000E+01	1.00531E+02	2.13628E+02	2.75161E-04
7	1		1.80000E+01	1.90000E+01	1.13097E+02	2.38761E+02	2.71202E-04
8	1		2.00000E+01	2.07500E+01	1.25664E+02	1.95564E+02	2.69086E-04
9	1		2.15000E+01	2.20000E+01	1.35088E+02	1.38230E+02	2.68915E-04
10	1		2.25000E+01	2.30000E+01	1.41372E+02	1.44513E+02	2.70335E-04
11	2		2.35000E+01	2.38750E+01	1.47655E+02	1.12508E+02	2.72877E-04
12	2		2.42500E+01	2.46250E+01	1.52367E+02	1.16043E+02	2.76551E-04
13	2		2.50000E+01	2.52500E+01	1.57080E+02	7.93252E+01	2.81031E-04
14	2		2.55000E+01	2.57500E+01	1.60221E+02	8.08960E+01	2.85784E-04
15	2		2.60000E+01	2.62500E+01	1.63363E+02	8.24668E+01	2.91954E-04
16	2		2.65000E+01	2.67500E+01	1.66504E+02	8.40376E+01	2.99841E-04
17	2		2.70000E+01	2.72500E+01	1.69646E+02	8.56084E+01	3.09930E-04
18	2		2.75000E+01	2.77500E+01	1.72788E+02	8.71792E+01	3.22889E-04
19	2		2.80000E+01	2.82500E+01	1.75929E+02	8.87500E+01	3.39659E-04
20	2		2.85000E+01	2.87500E+01	1.79071E+02	9.03208E+01	3.61613E-04
21	3		2.90000E+01	2.92500E+01	1.82212E+02	9.18916E+01	3.90833E-04
22	3		2.95000E+01	2.97500E+01	1.85354E+02	9.34624E+01	4.30678E-04
23	3		3.00000E+01	3.02000E+01	1.88496E+02	7.59009E+01	4.81676E-04
24	3		3.04000E+01	3.05500E+01	1.91009E+02	5.75854E+01	5.34572E-04
25	3		3.07000E+01	3.08500E+01	1.92894E+02	5.81509E+01	5.98792E-04
26	3		3.10000E+01	3.11500E+01	1.94779E+02	5.87164E+01	6.89936E-04
27	4		3.13000E+01	3.14500E+01	1.96664E+02	5.92819E+01	0.
28	4		3.16000E+01	3.17500E+01	1.98549E+02	5.98473E+01	0.
29	4		3.19000E+01	3.20500E+01	2.00434E+02	6.04128E+01	0.
30	4		3.22000E+01	3.24000E+01	2.02319E+02	8.14301E+01	0.
31	4		3.26000E+01	3.28000E+01	2.04832E+02	8.24354E+01	0.
32	4		3.30000E+01	3.32500E+01	2.07345E+02	1.04458E+02	0.
33	4		3.35000E+01	3.37500E+01	2.10487E+02	1.06029E+02	0.
34	5		3.40000E+01	3.42500E+01	2.13628E+02	1.07600E+02	0.
35	5		3.45000E+01	3.47500E+01	2.16770E+02	1.09170E+02	0.
36	5		3.50000E+01	3.52500E+01	2.19911E+02	1.10741E+02	0.
37	5		3.55000E+01	3.57500E+01	2.23053E+02	1.12312E+02	0.
38	5		3.60000E+01	3.62500E+01	2.26195E+02	1.13883E+02	0.
39	6		3.65000E+01	3.67500E+01	2.29336E+02	1.15454E+02	0.
40	6		3.70000E+01	3.73750E+01	2.32478E+02	1.76126E+02	0.
41	6		3.77500E+01	3.81250E+01	2.37190E+02	1.79660E+02	0.
42	6		3.85000E+01	3.88750E+01	2.41903E+02	1.83194E+02	0.
43	6		3.92500E+01	3.96250E+01	2.46615E+02	1.86728E+02	0.
44	6		4.00000E+01	4.03750E+01	2.51327E+02	1.90263E+02	0.

TABLE 2-4 (CONTINUED)

45	6	4.07500E+01	4.11250E+01	2.56040E+02	1.93797E+02	0.
46	6	4.15000E+01	4.18750E+01	2.60752E+02	1.97331E+02	0.
47	6	4.22500E+01	4.26250E+01	2.65465E+02	2.00866E+02	0.
48	6	4.30000E+01	4.33500E+01	2.70177E+02	1.90663E+02	0.
49		4.37000E+01		2.74575E+02		

TABLE 2-4 (CONTINUED)

SAMPLE PROBLEM ANISN USERS MANUAL 9

TOTAL FLUX

INT.	GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5	GROUP 6	GROUP 7	GROUP 8
1	1.30949E-03	3.92062E-03	2.90192E-03	4.11612E-03	6.04384E-03	7.76887E-03	3.29940E-03	5.94291E-03
2	1.29735E-03	3.88100E-03	2.87202E-03	4.07347E-03	5.97825E-03	7.67653E-03	3.25848E-03	5.86796E-03
3	1.27699E-03	3.81423E-03	2.82207E-03	4.00244E-03	5.86834E-03	7.52102E-03	3.18966E-03	5.74282E-03
4	1.24927E-03	3.72150E-03	2.75229E-03	3.90283E-03	5.71235E-03	7.29905E-03	3.09170E-03	5.56697E-03
5	1.21528E-03	3.60416E-03	2.66323E-03	3.77518E-03	5.50940E-03	7.00902E-03	2.96444E-03	5.34286E-03
6	1.18340E-03	3.48995E-03	2.57577E-03	3.64940E-03	5.30651E-03	6.71871E-03	2.83804E-03	5.12472E-03
7	1.15574E-03	3.38568E-03	2.49500E-03	3.53294E-03	5.11549E-03	6.44616E-03	2.72084E-03	4.92765E-03
8	1.13057E-03	3.28626E-03	2.41732E-03	3.42085E-03	4.92926E-03	6.18205E-03	2.60872E-03	4.74335E-03
9	1.11204E-03	3.20978E-03	2.35714E-03	3.33415E-03	4.78361E-03	5.97726E-03	2.52301E-03	4.60549E-03
10	1.09674E-03	3.14428E-03	2.30540E-03	3.25992E-03	4.65784E-03	5.80239E-03	2.45094E-03	4.49190E-03
11	1.08288E-03	3.08374E-03	2.25756E-03	3.19168E-03	4.54160E-03	5.64247E-03	2.38589E-03	4.39097E-03
12	1.07034E-03	3.02842E-03	2.21396E-03	3.13004E-03	4.43621E-03	5.49939E-03	2.32858E-03	4.30350E-03
13	1.05928E-03	2.97978E-03	2.17580E-03	3.07659E-03	4.34469E-03	5.37654E-03	2.28000E-03	4.23026E-03
14	1.04973E-03	2.93837E-03	2.14355E-03	3.03197E-03	4.26827E-03	5.27535E-03	2.24056E-03	4.17153E-03
15	1.03935E-03	2.89444E-03	2.10963E-03	2.98564E-03	4.18906E-03	5.17181E-03	2.20073E-03	4.11284E-03
16	1.02785E-03	2.84743E-03	2.07372E-03	2.93736E-03	4.10683E-03	5.06590E-03	2.16059E-03	4.05433E-03
17	1.01481E-03	2.79658E-03	2.03541E-03	2.88683E-03	4.02128E-03	4.95762E-03	2.12025E-03	3.99613E-03
18	9.99691E-04	2.74090E-03	1.99414E-03	2.83364E-03	3.93204E-03	4.84695E-03	2.07981E-03	3.93841E-03
19	9.81722E-04	2.67909E-03	1.94916E-03	2.77720E-03	3.83861E-03	4.73388E-03	2.03942E-03	3.88137E-03
20	9.59876E-04	2.60939E-03	1.89946E-03	2.71673E-03	3.74035E-03	4.61838E-03	1.99926E-03	3.82526E-03
21	9.32731E-04	2.52944E-03	1.84365E-03	2.65112E-03	3.63636E-03	4.50043E-03	1.95959E-03	3.77036E-03
22	8.98304E-04	2.43598E-03	1.77978E-03	2.57879E-03	3.52538E-03	4.37998E-03	1.92073E-03	3.71704E-03
23	8.59443E-04	2.33774E-03	1.71383E-03	2.50658E-03	3.41858E-03	4.26949E-03	1.88671E-03	3.67069E-03
24	8.22132E-04	2.24891E-03	1.65505E-03	2.44409E-03	3.32964E-03	4.18206E-03	1.86115E-03	3.63603E-03
25	7.83142E-04	2.16076E-03	1.59735E-03	2.38426E-03	3.24787E-03	4.10593E-03	1.84015E-03	3.60761E-03
26	7.36307E-04	2.05938E-03	1.53152E-03	2.31733E-03	3.16010E-03	4.02866E-03	1.82016E-03	3.58053E-03
27	6.75678E-04	1.92909E-03	1.44013E-03	2.21703E-03	3.03931E-03	3.91980E-03	1.79150E-03	3.54171E-03
28	6.09839E-04	1.78442E-03	1.33329E-03	2.09103E-03	2.89250E-03	3.78012E-03	1.75110E-03	3.48661E-03
29	5.51797E-04	1.65322E-03	1.23682E-03	1.97216E-03	2.75266E-03	3.64117E-03	1.70646E-03	3.42456E-03
30	4.93046E-04	1.51609E-03	1.13623E-03	1.84249E-03	2.59798E-03	3.48093E-03	1.65049E-03	3.34452E-03
31	4.34580E-04	1.37523E-03	1.03296E-03	1.70389E-03	2.43004E-03	3.30074E-03	1.58362E-03	3.24594E-03
32	3.79256E-04	1.23651E-03	9.31073E-04	1.56077E-03	2.25292E-03	3.10320E-03	1.50596E-03	3.12696E-03
33	3.27249E-04	1.10093E-03	8.31142E-04	1.41476E-03	2.06828E-03	2.89035E-03	1.41856E-03	2.98797E-03
34	2.83861E-04	9.82902E-04	7.43670E-04	1.28197E-03	1.89632E-03	2.68552E-03	1.33118E-03	2.84344E-03
35	2.47404E-04	8.79613E-04	6.66630E-04	1.16118E-03	1.73626E-03	2.48920E-03	1.24483E-03	2.69521E-03
36	2.16563E-04	7.88776E-04	5.98423E-04	1.05125E-03	1.58738E-03	2.30165E-03	1.16019E-03	2.54478E-03
37	1.90303E-04	7.08528E-04	5.37765E-04	9.51154E-04	1.44900E-03	2.12296E-03	1.07775E-03	2.39340E-03
38	1.67804E-04	6.37335E-04	4.83611E-04	8.59965E-04	1.32044E-03	1.95306E-03	9.97850E-04	2.24209E-03
39	1.48415E-04	5.73923E-04	4.35097E-04	7.76824E-04	1.20106E-03	1.79178E-03	9.20697E-04	2.09168E-03
40	1.28065E-04	5.04823E-04	3.81897E-04	6.83965E-04	1.06487E-03	1.60307E-03	8.28737E-04	1.90631E-03
41	1.07406E-04	4.32151E-04	3.25633E-04	5.84177E-04	9.15609E-04	1.39121E-03	7.23787E-04	1.68809E-03
42	9.04160E-05	3.69847E-04	2.77090E-04	4.96565E-04	7.81552E-04	1.19557E-03	6.25150E-04	1.47577E-03

TABLE 2-4 (CONTINUED)

43	7.62952E-05	3.15978E-04	2.34855E-04	4.19141E-04	6.60602E-04	1.01447E-03	5.32439E-04	1.26992E-03
44	6.44357E-05	2.68954E-04	1.97711E-04	3.50060E-04	5.50666E-04	8.45979E-04	4.45072E-04	1.07054E-03
45	5.43641E-05	2.27419E-04	1.64550E-04	2.87513E-04	4.49573E-04	6.87891E-04	3.62252E-04	8.77077E-04
46	4.56892E-05	1.90165E-04	1.34287E-04	2.29583E-04	3.54872E-04	5.37408E-04	2.82839E-04	6.88017E-04
47	3.81213E-05	1.56050E-04	1.05733E-04	1.73950E-04	2.63402E-04	3.90234E-04	2.04901E-04	4.99831E-04
48	3.15552E-05	1.24957E-04	7.84221E-05	1.19428E-04	1.73728E-04	2.43846E-04	1.27508E-04	3.11339E-04

INT.	GROUP 9	GROUP 10	GROUP 11	GROUP 12	GROUP 13	GROUP 14	GROUP 15	GROUP 16
1	3.14548E-03	1.26730E-03	3.15905E-04	1.64284E-04	1.14568E-05	1.31987E-06	2.26323E-07	1.62379E-08
2	3.10847E-03	1.25490E-03	3.14459E-04	1.65503E-04	1.15864E-05	1.33831E-06	2.29292E-07	1.64303E-08
3	3.04745E-03	1.23510E-03	3.12709E-04	1.68293E-04	1.18735E-05	1.38052E-06	2.35919E-07	1.68635E-08
4	2.96356E-03	1.20959E-03	3.11942E-04	1.74089E-04	1.24671E-05	1.47668E-06	2.50790E-07	1.77849E-08
5	2.86027E-03	1.18176E-03	3.14495E-04	1.85266E-04	1.36740E-05	1.71795E-06	2.89349E-07	1.98328E-08
6	2.76361E-03	1.15990E-03	3.21026E-04	2.00360E-04	1.54393E-05	2.15175E-06	3.66566E-07	2.31539E-08
7	2.68110E-03	1.14699E-03	3.32367E-04	2.19452E-04	1.79943E-05	2.96734E-06	5.40932E-07	2.90273E-08
8	2.60818E-03	1.14124E-03	3.48123E-04	2.42269E-04	2.14908E-05	4.33594E-06	9.10974E-07	3.92173E-08
9	2.55695E-03	1.14205E-03	3.64140E-04	2.63286E-04	2.51689E-05	6.03131E-06	1.39645E-06	5.31884E-08
10	2.51758E-03	1.14729E-03	3.81170E-04	2.84053E-04	2.93402E-05	8.26914E-06	2.25841E-06	7.54412E-08
11	2.48471E-03	1.15543E-03	3.99268E-04	3.05093E-04	3.40592E-05	1.11199E-05	3.32261E-06	1.09336E-07
12	2.45837E-03	1.16608E-03	4.18036E-04	3.25940E-04	3.93335E-05	1.43527E-05	4.81528E-06	1.64730E-07
13	2.43777E-03	1.17753E-03	4.35922E-04	3.45190E-04	4.46714E-05	1.82566E-05	6.62246E-06	2.43062E-07
14	2.42260E-03	1.18902E-03	4.52277E-04	3.62246E-04	4.98828E-05	2.19527E-05	8.66363E-06	3.36702E-07
15	2.40866E-03	1.20268E-03	4.70502E-04	3.80765E-04	5.60402E-05	2.67433E-05	1.13916E-05	4.84894E-07
16	2.39615E-03	1.21875E-03	4.90822E-04	4.00873E-04	6.33471E-05	3.27172E-05	1.50517E-05	7.17015E-07
17	2.38529E-03	1.23757E-03	5.13509E-04	4.22715E-04	7.20629E-05	4.01922E-05	1.99823E-05	1.08443E-06
18	2.37633E-03	1.25951E-03	5.38887E-04	4.46455E-04	8.25253E-05	4.95835E-05	2.66556E-05	1.67201E-06
19	2.36961E-03	1.28507E-03	5.67365E-04	4.72290E-04	9.51858E-05	6.14430E-05	3.57424E-05	2.62109E-06
20	2.36556E-03	1.31487E-03	5.99461E-04	5.00456E-04	1.10667E-04	7.65219E-05	4.82201E-05	4.17081E-06
21	2.36470E-03	1.34971E-03	6.35851E-04	5.31246E-04	1.29858E-04	9.58738E-05	6.55676E-05	6.73972E-06
22	2.36778E-03	1.39071E-03	6.77446E-04	5.65032E-04	1.54072E-04	1.21034E-04	9.01410E-05	1.11167E-05
23	2.37444E-03	1.43367E-03	7.19969E-04	5.98210E-04	1.81315E-04	1.54096E-04	1.22248E-04	1.77890E-05
24	2.38286E-03	1.47212E-03	7.57252E-04	6.26191E-04	2.08236E-04	1.84648E-04	1.56003E-04	2.64791E-05
25	2.39305E-03	1.50970E-03	7.93043E-04	6.52055E-04	2.35469E-04	2.19274E-04	2.00424E-04	3.81398E-05
26	2.40633E-03	1.55208E-03	8.32792E-04	6.79766E-04	2.69372E-04	2.61028E-04	2.59076E-04	6.11789E-05
27	2.42393E-03	1.60902E-03	8.87345E-04	7.18410E-04	3.17765E-04	3.23777E-04	3.43620E-04	9.09871E-05
28	2.43759E-03	1.67039E-03	9.49361E-04	7.64521E-04	3.52274E-04	3.67200E-04	4.00261E-04	1.11453E-04
29	2.43930E-03	1.71794E-03	1.00172E-03	8.05831E-04	3.94713E-04	4.14960E-04	4.62837E-04	1.27667E-04
30	2.42823E-03	1.75790E-03	1.05163E-03	8.47919E-04	4.37027E-04	4.72027E-04	5.37991E-04	1.48788E-04
31	2.40331E-03	1.78858E-03	1.09753E-03	8.89379E-04	4.78633E-04	5.30403E-04	6.15592E-04	1.73123E-04
32	2.36074E-03	1.80468E-03	1.13502E-03	9.26839E-04	5.17135E-04	5.87114E-04	6.92133E-04	1.97090E-04
33	2.30034E-03	1.80527E-03	1.16283E-03	9.58703E-04	5.51845E-04	6.40874E-04	7.66013E-04	2.20280E-04
34	2.22799E-03	1.78930E-03	1.17689E-03	9.80177E-04	5.78396E-04	6.84812E-04	8.27878E-04	2.39817E-04
35	2.14599E-03	1.75918E-03	1.17870E-03	9.91761E-04	5.97404E-04	7.19266E-04	8.77927E-04	2.55785E-04
36	2.05620E-03	1.71688E-03	1.16955E-03	9.93976E-04	6.09331E-04	7.44489E-04	9.16275E-04	2.68219E-04
37	1.96019E-03	1.66410E-03	1.15058E-03	9.87369E-04	6.14572E-04	7.60731E-04	9.43055E-04	2.77151E-04
38	1.85925E-03	1.60231E-03	1.12283E-03	9.72510E-04	6.13500E-04	7.68262E-04	9.58458E-04	2.82627E-04
39	1.75453E-03	1.53283E-03	1.08728E-03	9.49988E-04	6.06483E-04	7.67394E-04	9.62754E-04	2.84718E-04

TABLE 2-4 (CONTINUED)

40	1.61950E-03	1.43617E-03	1.03234E-03	9.11029E-04	5.89152E-04	7.53898E-04	9.51481E-04	2.82237E-04
41	1.45430E-03	1.31067E-03	9.55695E-04	8.52704E-04	5.58978E-04	7.23785E-04	9.19056E-04	2.73450E-04
42	1.28697E-03	1.17614E-03	8.68196E-04	7.82125E-04	5.18641E-04	6.78260E-04	8.65465E-04	2.58132E-04
43	1.11911E-03	1.03495E-03	7.72007E-04	7.01175E-04	4.69447E-04	6.18987E-04	7.92749E-04	2.36887E-04
44	9.51759E-04	8.88996E-04	6.68958E-04	6.11589E-04	4.12675E-04	5.47715E-04	7.03146E-04	2.10393E-04
45	7.85370E-04	7.39546E-04	5.60467E-04	5.14848E-04	3.49498E-04	4.66160E-04	5.98944E-04	1.79352E-04
46	6.19478E-04	5.86985E-04	4.47287E-04	4.11912E-04	2.80796E-04	3.75742E-04	4.82125E-04	1.44388E-04
47	4.51725E-04	4.29861E-04	3.28782E-04	3.02467E-04	2.06639E-04	2.76877E-04	3.53324E-04	1.05731E-04
48	2.81845E-04	2.68721E-04	2.05880E-04	1.87499E-04	1.28061E-04	1.71364E-04	2.14432E-04	6.39844E-05

TABLE 2-4 (CONTINUED)

SUMMARY FOR ZONE 1 BY GROUP INCLUDING SUM FOR ALL GROUPS IN LINE 17

GRP.	FIX SOURCE	FISS SOURCE	IN SCATTER	SLF SCATTER	OUT SCATTER	ABSORPTION	LEAKAGE	BALANCE
1	0.	1.12812E-01	0.	1.47920E-01	9.73385E-02	5.76007E-03	9.71372E-03	9.99997E-01
2	0.	1.71261E-01	8.98442E-02	5.89096E-01	2.15743E-01	1.50399E-02	3.03240E-02	9.99996E-01
3	0.	8.94606E-02	2.12363E-01	5.03163E-01	2.75291E-01	9.19933E-03	1.73353E-02	9.99997E-01
4	0.	7.54385E-02	2.79799E-01	1.09165E+00	3.25738E-01	1.13103E-02	1.81929E-02	9.99995E-01
5	0.	3.89698E-02	3.30773E-01	2.31940E+00	3.30015E-01	1.63650E-02	2.33725E-02	9.99988E-01
6	0.	7.61616E-03	3.31196E-01	3.61309E+00	2.83303E-01	2.84998E-02	2.70188E-02	9.99986E-01
7	0.	1.29469E-04	2.83406E-01	1.36386E+00	2.53214E-01	1.93362E-02	1.09872E-02	9.99996E-01
8	0.	0.	2.53256E-01	2.76796E+00	1.78311E-01	5.82514E-02	1.66983E-02	9.99991E-01
9	0.	0.	1.78318E-01	1.49524E+00	9.81103E-02	7.51907E-02	5.01827E-03	9.99995E-01
10	0.	0.	9.81122E-02	6.45846E-01	2.87237E-02	7.10737E-02	-1.68527E-03	1.00000E+00
11	0.	0.	2.87248E-02	1.73841E-01	1.49504E-02	1.69859E-02	-3.21170E-03	1.00000E+00
12	0.	0.	1.51165E-02	1.12544E-01	4.05497E-03	1.45615E-02	-3.49971E-03	9.99993E-01
13	0.	0.	3.97485E-03	8.95704E-03	8.33984E-04	3.85045E-03	-7.09534E-04	9.99994E-01
14	0.	0.	6.80473E-04	1.66618E-03	1.38394E-04	9.40454E-04	-3.98364E-04	9.99992E-01
15	0.	0.	1.95551E-04	3.81401E-04	1.78626E-05	3.16653E-04	-1.38961E-04	9.99992E-01
16	0.	0.	2.84285E-05	1.88392E-05	6.49231E-07	3.04337E-05	-2.65397E-06	9.99993E-01
17	0.	4.95687E-01	2.10579E+00	1.48346E+01	2.10578E+00	3.46712E-01	1.49015E-01	9.99993E-01

GRP.	RT BDY FLUX	RT BDY J+	RT BDY J	RT LEAKAGE	LFT LEAKAGE	FISS RATE	TOTAL FLUX	DENSITY
1	1.08897E-03	3.12720E-04	6.57867E-05	9.71372E-03	0.	4.72266E-03	2.06995E+00	2.06995E+00
2	3.11057E-03	9.05985E-04	2.05371E-04	3.03240E-02	0.	1.22750E-02	6.09701E+00	6.09701E+00
3	2.27875E-03	6.49995E-04	1.17404E-04	1.73353E-02	0.	8.11689E-03	4.49799E+00	4.49799E+00
4	3.22178E-03	9.00980E-04	1.23213E-04	1.81929E-02	0.	1.08567E-02	6.37245E+00	6.37245E+00
5	4.59300E-03	1.27740E-03	1.58292E-04	2.33725E-02	0.	1.82864E-02	9.26124E+00	9.26124E+00
6	5.71271E-03	1.58374E-03	1.82986E-04	2.70188E-02	0.	3.70024E-02	1.17374E+01	1.17374E+01
7	2.41423E-03	6.68323E-04	7.44116E-05	1.09872E-02	0.	2.91178E-02	4.96418E+00	4.96418E+00
8	4.43455E-03	1.21644E-03	1.13090E-04	1.66983E-02	0.	8.60567E-02	8.97895E+00	8.97895E+00
9	2.49834E-03	6.71347E-04	3.39865E-05	5.01827E-03	0.	1.14273E-01	4.85068E+00	4.85068E+00
10	1.15097E-03	2.96749E-04	-1.14136E-05	-1.68527E-03	0.	1.02848E-01	2.04538E+00	2.04538E+00
11	3.90651E-04	9.25813E-05	-2.17514E-05	-3.21170E-03	0.	2.20485E-02	5.73596E-01	5.73596E-01
12	2.95318E-04	6.63704E-05	-2.37020E-05	-3.49971E-03	0.	2.94740E-02	3.60776E-01	3.60776E-01
13	3.17311E-05	6.27509E-06	-4.80536E-06	-7.09534E-04	0.	7.62947E-03	2.96359E-02	2.96359E-02
14	9.62417E-06	1.43303E-06	-2.69794E-06	-3.98364E-04	0.	1.93664E-03	5.26075E-03	5.26075E-03
15	2.79896E-06	3.58242E-07	-9.41118E-07	-1.38961E-04	0.	6.53102E-04	1.11141E-03	1.11141E-03
16	8.99354E-08	1.64804E-08	-1.79742E-08	-2.65397E-06	0.	6.28348E-05	5.22983E-05	5.22983E-05
17	3.12341E-02	8.65070E-03	1.00921E-03	1.49015E-01	0.	4.85360E-01	6.18457E+01	6.18457E+01

TABLE 2-4 (CONTINUED)

SUMMARY FOR ZONE 2 BY GROUP INCLUDING SUM FOR ALL GROUPS IN LINE 17

GRP.	FIX SOURCE	FISS SOURCE	IN SCATTER	SLF SCATTER	OUT SCATTER	ABSORPTION	LEAKAGE	BALANCE
1	0.	6.39100E-02	0.	6.68105E-02	4.39646E-02	2.60163E-03	1.73437E-02	1.00000E+00
2	0.	9.70226E-02	4.05796E-02	2.51430E-01	9.20805E-02	6.41912E-03	3.91022E-02	1.00000E+00
3	0.	5.06812E-02	9.07238E-02	2.12295E-01	1.16151E-01	3.88139E-03	2.13725E-02	1.00000E+00
4	0.	4.27374E-02	1.18161E-01	4.60942E-01	1.37541E-01	4.77569E-03	1.85814E-02	1.00000E+00
5	0.	2.20771E-02	1.39707E-01	9.44624E-01	1.34405E-01	6.66498E-03	2.07127E-02	1.00000E+00
6	0.	4.31470E-03	1.34908E-01	1.43530E+00	1.12542E-01	1.13216E-02	1.53592E-02	1.00000E+00
7	0.	7.33465E-05	1.12585E-01	5.46243E-01	1.01416E-01	7.74441E-03	3.49860E-03	9.99999E-01
8	0.	0.	1.01433E-01	1.14731E+00	7.39094E-02	2.41450E-02	3.37842E-03	1.00000E+00
9	0.	0.	7.39121E-02	6.74924E-01	4.42853E-02	3.39398E-02	-4.31315E-03	1.00000E+00
10	0.	0.	4.42862E-02	3.48933E-01	1.55187E-02	3.83992E-02	-9.63176E-03	1.00000E+00
11	0.	0.	1.55192E-02	1.33377E-01	1.14705E-02	1.30322E-02	-8.98349E-03	9.99999E-01
12	0.	0.	1.17945E-02	1.11101E-01	4.00299E-03	1.43748E-02	-6.58318E-03	9.99993E-01
13	0.	0.	4.25472E-03	1.74472E-02	1.62450E-03	7.50021E-03	-4.86996E-03	9.99996E-01
14	0.	0.	1.38209E-03	9.88912E-03	8.21400E-04	5.58179E-03	-5.02109E-03	9.99999E-01
15	0.	0.	6.36703E-04	5.46495E-03	2.55947E-04	4.53719E-03	-4.15644E-03	9.99998E-01
16	0.	0.	1.19736E-04	3.69633E-04	1.27382E-05	5.97121E-04	-4.90122E-04	9.99996E-01
17	0.	2.80816E-01	8.90003E-01	6.36646E+00	8.90001E-01	1.85516E-01	9.52997E-02	1.00000E+00

GRP.	RT BDY FLUX	RT BDY J+	RT BDY J	RT LEAKAGE	LFT LEAKAGE	FISS RATE	TOTAL FLUX	DENSITY
1	9.47835E-04	3.12592E-04	1.48494E-04	2.70574E-02	9.71372E-03	2.13307E-03	9.34928E-01	9.34928E-01
2	2.57232E-03	8.46987E-04	3.81018E-04	6.94262E-02	3.03240E-02	5.23905E-03	2.60224E+00	2.60224E+00
3	1.87328E-03	5.87338E-04	2.12432E-04	3.87078E-02	1.73353E-02	3.42469E-03	1.89780E+00	1.89780E+00
4	2.68537E-03	7.95907E-04	2.01822E-04	3.67744E-02	1.81929E-02	4.58418E-03	2.69072E+00	2.69072E+00
5	3.68991E-03	1.08067E-03	2.41944E-04	4.40853E-02	2.33725E-02	7.44751E-03	3.77183E+00	3.77183E+00
6	4.56002E-03	1.30752E-03	2.32575E-04	4.23780E-02	2.70188E-02	1.46992E-02	4.66270E+00	4.66270E+00
7	1.97927E-03	5.57807E-04	7.94997E-05	1.44858E-02	1.09872E-02	1.16621E-02	1.98822E+00	1.98822E+00
8	3.79746E-03	1.04893E-03	1.10183E-04	2.00767E-02	1.66983E-02	3.56702E-02	3.72175E+00	3.72175E+00
9	2.36425E-03	6.21890E-04	3.86976E-06	7.05118E-04	5.01827E-03	5.15808E-02	2.18951E+00	2.18951E+00
10	1.33091E-03	3.19756E-04	-6.21090E-05	-1.13170E-02	-1.68527E-03	5.55660E-02	1.10507E+00	1.10507E+00
11	6.16486E-04	1.30341E-04	-6.69284E-05	-1.21952E-02	-3.21170E-03	1.69164E-02	4.40084E-01	4.40084E-01
12	5.15155E-04	1.08516E-04	-5.53359E-05	-1.00829E-02	-3.49971E-03	2.90961E-02	3.56151E-01	3.56151E-01
13	1.19204E-04	1.81255E-05	-3.06208E-05	-5.57949E-03	-7.09534E-04	1.48613E-02	5.77272E-02	5.77272E-02
14	8.62758E-05	1.01883E-05	-2.97425E-05	-5.41946E-03	-3.98364E-04	1.14944E-02	3.12236E-02	3.12236E-02
15	5.68045E-05	5.45163E-06	-2.35736E-05	-4.29540E-03	-1.38961E-04	9.35806E-03	1.59250E-02	1.59250E-02
16	5.34715E-06	3.86527E-07	-2.70440E-06	-4.92776E-04	-2.65397E-06	1.23284E-03	1.02611E-03	1.02611E-03
17	2.71999E-02	7.75240E-03	1.34082E-03	2.44315E-01	1.49015E-01	2.74966E-01	2.64669E+01	2.64669E+01

TABLE 2-4 (CONTINUED)

SUMMARY FOR ZONE 3 BY GROUP INCLUDING SUM FOR ALL GROUPS IN LINE 17

GRP.	FIX SOURCE	FISS SOURCE	IN SCATTER	SLF SCATTER	OUT SCATTER	ABSORPTION	LEAKAGE	BALANCE
1	0.	5.08648E-02	0.	2.65131E-02	1.74469E-02	1.03243E-03	3.23850E-02	1.00000E+00
2	0.	7.72184E-02	1.61036E-02	9.79361E-02	3.58669E-02	2.50035E-03	5.49540E-02	1.00000E+00
3	0.	4.03362E-02	3.53499E-02	8.32222E-02	4.55325E-02	1.52155E-03	2.86315E-02	1.00000E+00
4	0.	3.40139E-02	4.63217E-02	1.86785E-01	5.57347E-02	1.93522E-03	2.26650E-02	1.00000E+00
5	0.	1.75708E-02	5.65803E-02	3.72976E-01	5.30686E-02	2.63160E-03	1.84494E-02	1.00001E+00
6	0.	3.43399E-03	5.32693E-02	5.73514E-01	4.49693E-02	4.52384E-03	7.20906E-03	1.00001E+00
7	0.	5.83750E-05	4.49864E-02	2.26343E-01	4.20228E-02	3.20899E-03	-1.87136E-04	1.00000E+00
8	0.	0.	4.20299E-02	4.93815E-01	3.18114E-02	1.03923E-02	-1.74186E-04	1.00000E+00
9	0.	0.	3.18126E-02	3.19499E-01	2.09640E-02	1.60666E-02	-5.21817E-03	1.00000E+00
10	0.	0.	2.09644E-02	1.97829E-01	8.79834E-03	2.17705E-02	-9.60440E-03	1.00000E+00
11	0.	0.	8.79865E-03	9.54715E-02	8.21062E-03	9.32848E-03	-8.74041E-03	9.99998E-01
12	0.	0.	8.66873E-03	8.13944E-02	2.93265E-03	1.05312E-02	-4.79505E-03	9.99995E-01
13	0.	0.	3.74155E-03	2.46611E-02	2.29617E-03	1.06013E-02	-9.15591E-03	9.99999E-01
14	0.	0.	2.35505E-03	2.23378E-02	1.85540E-03	1.26083E-02	-1.21087E-02	1.00000E+00
15	0.	0.	1.30838E-03	2.04456E-02	9.57553E-04	1.69747E-02	-1.66238E-02	1.00000E+00
16	0.	0.	3.06828E-04	3.72596E-03	1.28403E-04	6.01908E-03	-5.84066E-03	1.00000E+00
17	0.	2.23496E-01	3.72597E-01	2.82647E+00	3.72596E-01	1.31646E-01	9.18455E-02	1.00000E+00

GRP.	RT BDY FLUX	RT BDY J+	RT BDY J-	RT LEAKAGE	LFT LEAKAGE	FISS RATE	TOTAL FLUX	DENSITY
1	7.10691E-04	3.36434E-04	3.02254E-04	5.94425E-02	2.70574E-02	8.46486E-04	3.71017E-01	3.71017E-01
2	2.00500E-03	8.41027E-04	6.32452E-04	1.24380E-01	6.94262E-02	2.04070E-03	1.01362E+00	1.01362E+00
3	1.49633E-03	5.61787E-04	3.42408E-04	6.73393E-02	3.87078E-02	1.34252E-03	7.43959E-01	7.43959E-01
4	2.28187E-03	7.44828E-04	3.02239E-04	5.94394E-02	3.67744E-02	1.85762E-03	1.09034E+00	1.09034E+00
5	3.11455E-03	9.72335E-04	3.17977E-04	6.25346E-02	4.40853E-02	2.94058E-03	1.48927E+00	1.48927E+00
6	3.98973E-03	1.16943E-03	2.52141E-04	4.95870E-02	4.23780E-02	5.87347E-03	1.86311E+00	1.86311E+00
7	1.81045E-03	5.09305E-04	7.27064E-05	1.42987E-02	1.44858E-02	4.83233E-03	8.23843E-01	8.23843E-01
8	3.56736E-03	9.82074E-04	1.01201E-04	1.99025E-02	2.00767E-02	1.53529E-02	1.60188E+00	1.60188E+00
9	2.41380E-03	6.17391E-04	-2.29481E-05	-4.51305E-03	7.05118E-04	2.44176E-02	1.03648E+00	1.03648E+00
10	1.57458E-03	3.56330E-04	-1.06382E-04	-2.09214E-02	-1.13170E-02	3.15033E-02	6.26519E-01	6.26519E-01
11	8.53737E-04	1.68893E-04	-1.06454E-04	-2.09356E-02	-1.21952E-02	1.21088E-02	3.15013E-01	3.15013E-01
12	6.94112E-04	1.43029E-04	-7.56517E-05	-1.48779E-02	-1.00829E-02	2.13163E-02	2.60921E-01	2.60921E-01
13	2.84023E-04	3.75475E-05	-7.49269E-05	-1.47354E-02	-5.57949E-03	2.10059E-02	8.15954E-02	8.15954E-02
14	2.80394E-04	3.04714E-05	-8.91274E-05	-1.75281E-02	-5.41946E-03	2.59638E-02	7.05288E-02	7.05288E-02
15	2.87615E-04	2.46160E-05	-1.06371E-04	-2.09192E-02	-4.29540E-03	3.50106E-02	5.95790E-02	5.95790E-02
16	7.35931E-05	4.05449E-06	-3.22044E-05	-6.33343E-03	-4.92776E-04	1.24273E-02	1.03434E-02	1.03434E-02
17	2.54378E-02	7.49956E-03	1.70931E-03	3.36160E-01	2.44315E-01	2.18840E-01	1.14580E+01	1.14580E+01

TABLE 2-4 (CONTINUED)

SUMMARY FOR ZONE 4 BY GROUP INCLUDING SUM FOR ALL GROUPS IN LINE 17

GRP.	FIX SOURCE	FISS SOURCE	IN SCATTER	SLF SCATTER	OUT SCATTER	ABSORPTION	LEAKAGE	BALANCE
1	0.	0.	0.	1.70227E-02	3.82262E-02	-1.12973E-02	-2.69290E-02	1.00000E+00
2	0.	0.	1.98543E-02	8.90100E-02	5.67471E-02	7.56860E-03	-4.44617E-02	1.00001E+00
3	0.	0.	5.66914E-02	8.98371E-02	8.09104E-02	7.59419E-04	-2.49787E-02	1.00000E+00
4	0.	0.	9.38886E-02	2.87830E-01	1.07279E-01	5.41004E-04	-1.39324E-02	1.00001E+00
5	0.	0.	1.11246E-01	5.32995E-01	1.22183E-01	6.61394E-04	-1.16011E-02	1.00001E+00
6	0.	0.	1.23570E-01	9.87392E-01	1.24176E-01	7.25826E-04	-1.33465E-03	1.00001E+00
7	0.	0.	1.24271E-01	4.15427E-01	1.18091E-01	3.45045E-04	5.83453E-03	1.00000E+00
8	0.	0.	1.18091E-01	9.04401E-01	1.03898E-01	6.81277E-04	1.35108E-02	1.00001E+00
9	0.	0.	1.03898E-01	7.13591E-01	8.25411E-02	5.17005E-04	2.08396E-02	1.00000E+00
10	0.	0.	8.25415E-02	5.25323E-01	5.80480E-02	4.15468E-04	2.40779E-02	1.00000E+00
11	0.	0.	5.80483E-02	3.13332E-01	4.03679E-02	3.04984E-04	1.73753E-02	1.00000E+00
12	0.	0.	4.22563E-02	2.71200E-01	3.17723E-02	3.39078E-04	1.01450E-02	9.99999E-01
13	0.	0.	4.11055E-02	1.28086E-01	3.19627E-02	2.65797E-04	8.87708E-03	1.00000E+00
14	0.	0.	4.05567E-02	1.46153E-01	3.20604E-02	3.85026E-04	8.11124E-03	1.00000E+00
15	0.	0.	2.51552E-02	2.10091E-01	1.57592E-02	5.96596E-04	8.79941E-03	1.00000E+00
16	0.	0.	6.86184E-03	6.01757E-02	4.01323E-03	2.89376E-04	2.55924E-03	1.00000E+00
17	0.	0.	1.04804E+00	5.77187E+00	1.04804E+00	3.09864E-03	-3.10751E-03	1.00000E+00

GRP.	RT BDY FLUX	RT BDY J+	RT BDY J	RT LEAKAGE	LFT LEAKAGE	FISS RATE	TOTAL FLUX	DENSITY
1	3.03637E-04	1.68020E-04	1.52196E-04	3.25134E-02	5.94425E-02	0.	2.60176E-01	2.60176E-01
2	1.03792E-03	4.83433E-04	3.74101E-04	7.99186E-02	1.24380E-01	0.	8.03745E-01	8.03745E-01
3	7.84576E-04	3.16064E-04	1.98291E-04	4.23606E-02	6.73393E-02	0.	6.02946E-01	6.02946E-01
4	1.34522E-03	4.66225E-04	2.13019E-04	4.55070E-02	5.94394E-02	0.	9.79250E-01	9.79250E-01
5	1.97924E-03	6.43534E-04	2.38421E-04	5.09335E-02	6.25346E-02	0.	1.38609E+00	1.38609E+00
6	2.78585E-03	8.44784E-04	2.25871E-04	4.82524E-02	4.95870E-02	0.	1.86474E+00	1.86474E+00
7	1.37472E-03	4.06833E-04	9.42442E-05	2.01332E-02	1.42987E-02	0.	8.86758E-01	8.86758E-01
8	2.91683E-03	8.39539E-04	1.56409E-04	3.34133E-02	1.99025E-02	0.	1.80888E+00	1.80888E+00
9	2.26683E-03	6.27064E-04	7.64251E-05	1.63266E-02	-4.51305E-03	0.	1.32329E+00	1.32329E+00
10	1.80110E-03	4.72740E-04	1.47754E-05	3.15644E-03	-2.09214E-02	0.	9.69652E-01	9.69652E-01
11	1.17309E-03	2.93710E-04	-1.66660E-05	-3.56033E-03	-2.09356E-02	0.	5.87902E-01	5.87902E-01
12	9.71976E-04	2.39776E-04	-2.21551E-05	-4.73295E-03	-1.48779E-02	0.	4.77854E-01	4.77854E-01
13	5.67070E-04	1.32033E-04	-2.74230E-05	-5.85832E-03	-1.47354E-02	0.	2.51340E-01	2.51340E-01
14	6.65248E-04	1.48943E-04	-4.40807E-05	-9.41688E-03	-1.75281E-02	0.	2.77680E-01	2.77680E-01
15	7.99915E-04	1.77671E-04	-5.67332E-05	-1.21198E-02	-2.09192E-02	0.	3.20360E-01	3.20360E-01
16	2.30947E-04	5.06460E-05	-1.76671E-05	-3.77419E-03	-6.33343E-03	0.	9.01076E-02	9.01076E-02
17	2.10042E-02	6.31101E-03	1.55903E-03	3.33053E-01	3.36160E-01	0.	1.28908E+01	1.28908E+01

TABLE 2-4 (CONTINUED)

SUMMARY FOR ZONE 5 BY GROUP INCLUDING SUM FOR ALL GROUPS IN LINE 17

GRP.	FIX SOURCE	FISS SOURCE	IN SCATTER	SLF SCATTER	OUT SCATTER	ABSORPTION	LEAKAGE	BALANCE
1	0.	0.	0.	7.98338E-03	1.79275E-02	-5.29822E-03	-1.26292E-02	1.00000E+00
2	0.	0.	9.31131E-03	4.88708E-02	3.11569E-02	4.15553E-03	-2.60013E-02	1.00001E+00
3	0.	0.	3.07530E-02	4.98450E-02	4.48921E-02	4.21355E-04	-1.45607E-02	1.00000E+00
4	0.	0.	5.11463E-02	1.72208E-01	6.41849E-02	3.23682E-04	-1.33628E-02	1.00001E+00
5	0.	0.	6.61860E-02	3.39348E-01	7.77919E-02	4.21097E-04	-1.20288E-02	1.00001E+00
6	0.	0.	7.85087E-02	6.75886E-01	8.50005E-02	4.96840E-04	-6.99099E-03	1.00001E+00
7	0.	0.	8.50483E-02	3.00902E-01	8.55353E-02	2.49923E-04	-7.37514E-04	1.00000E+00
8	0.	0.	8.55358E-02	7.65228E-01	8.07656E-02	5.29594E-04	4.23953E-03	1.00001E+00
9	0.	0.	8.07657E-02	6.11302E-01	7.07092E-02	4.42895E-04	9.61320E-03	1.00000E+00
10	0.	0.	7.07096E-02	5.11470E-01	5.65172E-02	4.04512E-04	1.37878E-02	1.00000E+00
11	0.	0.	5.65175E-02	3.42124E-01	4.40773E-02	3.33009E-04	1.21071E-02	1.00000E+00
12	0.	0.	4.65856E-02	3.09567E-01	3.62673E-02	3.87048E-04	9.93127E-03	1.00000E+00
13	0.	0.	5.02112E-02	1.70121E-01	4.24519E-02	3.53024E-04	7.40611E-03	1.00000E+00
14	0.	0.	5.71699E-02	2.14526E-01	4.70589E-02	5.65150E-04	9.54562E-03	1.00000E+00
15	0.	0.	3.67621E-02	3.28857E-01	2.46679E-02	9.33854E-04	1.11602E-02	1.00000E+00
16	0.	0.	1.03302E-02	9.79992E-02	6.53575E-03	4.71265E-04	3.32318E-03	1.00000E+00
17	0.	0.	8.15541E-01	4.94624E+00	8.15540E-01	5.19056E-03	-5.19720E-03	1.00000E+00

GRP.	RT BDY FLUX	RT BDY J+	RT BDY J	RT LEAKAGE	LFT LEAKAGE	FISS RATE	TOTAL FLUX	DENSITY
1	1.57404E-04	9.51192E-05	8.67032E-05	1.98842E-02	3.25134E-02	0.	1.22018E-01	1.22018E-01
2	6.03828E-04	2.97556E-04	2.35102E-04	5.39173E-02	7.99186E-02	0.	4.41295E-01	4.41295E-01
3	4.58042E-04	1.89514E-04	1.21219E-04	2.77999E-02	4.23606E-02	0.	3.34537E-01	3.34537E-01
4	8.16485E-04	2.90280E-04	1.40162E-04	3.21441E-02	4.55070E-02	0.	5.85884E-01	5.85884E-01
5	1.25854E-03	4.19766E-04	1.69641E-04	3.89047E-02	5.09335E-02	0.	8.82496E-01	8.82496E-01
6	1.87030E-03	5.82649E-04	1.79917E-04	4.12614E-02	4.82524E-02	0.	1.27645E+00	1.27645E+00
7	9.58567E-04	2.94076E-04	8.45733E-05	1.93957E-02	2.01332E-02	0.	6.42295E-01	6.42295E-01
8	2.16656E-03	6.49248E-04	1.64182E-04	3.76528E-02	3.34133E-02	0.	1.40614E+00	1.40614E+00
9	1.80771E-03	5.27970E-04	1.13108E-04	2.59398E-02	1.63266E-02	0.	1.13360E+00	1.13360E+00
10	1.56934E-03	4.44486E-04	7.38840E-05	1.69443E-02	3.15644E-03	0.	9.44081E-01	9.44081E-01
11	1.10689E-03	3.05191E-04	3.72675E-05	8.54679E-03	-3.56033E-03	0.	6.41923E-01	6.41923E-01
12	9.63091E-04	2.60645E-04	2.26668E-05	5.19831E-03	-4.73295E-03	0.	5.45457E-01	5.45457E-01
13	6.11432E-04	1.61269E-04	6.74901E-06	1.54779E-03	-5.85832E-03	0.	3.33823E-01	3.33823E-01
14	7.69886E-04	1.98841E-04	5.61348E-07	1.28737E-04	-9.41688E-03	0.	4.07584E-01	4.07584E-01
15	9.63345E-04	2.46751E-04	-4.18419E-06	-9.59587E-04	-1.21198E-02	0.	5.01460E-01	5.01460E-01
16	2.84509E-04	7.24994E-05	-1.96661E-06	-4.51015E-04	-3.77419E-03	0.	1.46745E-01	1.46745E-01
17	1.63659E-02	5.03586E-03	1.42958E-03	3.27855E-01	3.33053E-01	0.	1.03458E+01	1.03458E+01

TABLE 2-4 (CONTINUED)

SUMMARY FOR ZONE 6 BY GROUP INCLUDING SUM FOR ALL GROUPS IN LINE 17

GRP.	FIX SOURCE	FISS SOURCE	IN SCATTER	SLF SCATTER	OUT SCATTER	ABSORPTION	LEAKAGE	BALANCE
1	0.	0.	0.	8.85134E-03	1.98765E-02	-5.87425E-03	-1.40023E-02	1.00000E+00
2	0.	0.	1.03236E-02	6.06335E-02	3.86560E-02	5.15572E-03	-3.34883E-02	1.00001E+00
3	0.	0.	3.78664E-02	6.00174E-02	5.40537E-02	5.07345E-04	-1.66949E-02	1.00000E+00
4	0.	0.	6.11447E-02	2.08594E-01	7.77465E-02	3.92072E-04	-1.69946E-02	1.00001E+00
5	0.	0.	8.00872E-02	4.24985E-01	9.74234E-02	5.27365E-04	-1.78658E-02	1.00001E+00
6	0.	0.	9.82781E-02	8.85757E-01	1.11394E-01	6.51115E-04	-1.37701E-02	1.00001E+00
7	0.	0.	1.11450E-01	4.08704E-01	1.16179E-01	3.39461E-04	-5.06947E-03	1.00000E+00
8	0.	0.	1.16180E-01	1.11953E+00	1.18160E-01	7.74797E-04	-2.75667E-03	1.00001E+00
9	0.	0.	1.18160E-01	9.67326E-01	1.11891E-01	7.00838E-04	5.56858E-03	1.00000E+00
10	0.	0.	1.11891E-01	8.88485E-01	9.81773E-02	7.02686E-04	1.30114E-02	9.99999E-01
11	0.	0.	9.81777E-02	6.45801E-01	8.32013E-02	6.28595E-04	1.43479E-02	9.99999E-01
12	0.	0.	8.86453E-02	6.19448E-01	7.25713E-02	7.74489E-04	1.52989E-02	1.00000E+00
13	0.	0.	1.05304E-01	3.69197E-01	9.21293E-02	7.66135E-04	1.24078E-02	1.00000E+00
14	0.	0.	1.29272E-01	4.99088E-01	1.09481E-01	1.31481E-03	1.84751E-02	1.00000E+00
15	0.	0.	8.52198E-02	7.91730E-01	5.93886E-02	2.24827E-03	2.35828E-02	1.00000E+00
16	0.	0.	2.43622E-02	2.40381E-01	1.60314E-02	1.15596E-03	7.17475E-03	1.00000E+00
17	0.	0.	1.27636E+00	8.19853E+00	1.27636E+00	1.07654E-02	-1.07747E-02	1.00000E+00

GRP.	RT BDY FLUX	RT BDY J+	RT BDY J	RT LEAKAGE	LFT LEAKAGE	FISS RATE	TOTAL FLUX	DENSITY
1	2.85430E-05	2.14217E-05	2.14217E-05	5.88188E-03	1.98842E-02	0.	1.35284E-01	1.35284E-01
2	1.10278E-04	7.44024E-05	7.44024E-05	2.04290E-02	5.39173E-02	0.	5.47510E-01	5.47510E-01
3	6.51196E-05	4.04443E-05	4.04443E-05	1.11050E-02	2.77999E-02	0.	4.02810E-01	4.02810E-01
4	9.24738E-05	5.51745E-05	5.51745E-05	1.51496E-02	3.21441E-02	0.	7.09675E-01	7.09675E-01
5	1.29440E-04	7.66237E-05	7.66237E-05	2.10390E-02	3.89047E-02	0.	1.10520E+00	1.10520E+00
6	1.70888E-04	1.00123E-04	1.00123E-04	2.74913E-02	4.12614E-02	0.	1.67280E+00	1.67280E+00
7	8.90265E-05	5.21760E-05	5.21760E-05	1.43262E-02	1.93957E-02	0.	8.72406E-01	8.72406E-01
8	2.17340E-04	1.27091E-04	1.27091E-04	3.48962E-02	3.76528E-02	0.	2.05719E+00	2.05719E+00
9	1.96765E-04	1.14753E-04	1.14753E-04	3.15083E-02	2.59398E-02	0.	1.79382E+00	1.79382E+00
10	1.87624E-04	1.09098E-04	1.09098E-04	2.99556E-02	1.69443E-02	0.	1.63998E+00	1.63998E+00
11	1.43760E-04	8.33824E-05	8.33824E-05	2.28947E-02	8.54679E-03	0.	1.21171E+00	1.21171E+00
12	1.29033E-04	7.46508E-05	7.46508E-05	2.04972E-02	5.19831E-03	0.	1.09147E+00	1.09147E+00
13	8.79909E-05	5.08262E-05	5.08262E-05	1.39556E-02	1.54779E-03	0.	7.24464E-01	7.24464E-01
14	1.17439E-04	6.77551E-05	6.77551E-05	1.86039E-02	1.28737E-04	0.	9.48234E-01	9.48234E-01
15	1.42988E-04	8.23936E-05	8.23936E-05	2.26232E-02	-9.59587E-04	0.	1.20728E+00	1.20728E+00
16	4.25003E-05	2.44878E-05	2.44878E-05	6.72374E-03	-4.51015E-04	0.	3.59948E-01	3.59948E-01
17	1.95121E-03	1.15480E-03	1.15480E-03	3.17081E-01	3.27855E-01	0.	1.64798E+01	1.64798E+01

TABLE 2-4 (CONTINUED)

SUMMARY FOR SYSTEM

GRP.	FIX SOURCE	FISS SOURCE	IN SCATTER	SLF SCATTER	OUT SCATTER	ABSORPTION	LEAKAGE	BALANCE
1	0.	2.27586E-01	0.	2.75101E-01	2.34780E-01	-1.30756E-02	5.88188E-03	1.00000E+00
2	0.	3.45502E-01	1.86017E-01	1.13698E+00	4.70250E-01	4.08392E-02	2.04290E-02	1.00000E+00
3	0.	1.80478E-01	4.63748E-01	9.98380E-01	6.16830E-01	1.62904E-02	1.11050E-02	1.00000E+00
4	0.	1.52190E-01	6.50461E-01	2.40801E+00	7.68224E-01	1.92779E-02	1.51496E-02	1.00000E+00
5	0.	7.86177E-02	7.84580E-01	4.93433E+00	8.14887E-01	2.72714E-02	2.10390E-02	1.00000E+00
6	0.	1.53649E-02	8.19731E-01	8.17094E+00	7.61385E-01	4.62190E-02	2.74913E-02	1.00000E+00
7	0.	2.61190E-04	7.61747E-01	3.26148E+00	7.16458E-01	3.12240E-02	1.43262E-02	1.00000E+00
8	0.	0.	7.16526E-01	7.27824E+00	5.86856E-01	9.47744E-02	3.48962E-02	1.00000E+00
9	0.	0.	5.86867E-01	4.78188E+00	4.28501E-01	1.26858E-01	3.15083E-02	1.00000E+00
10	0.	0.	4.28505E-01	3.11789E+00	2.65783E-01	1.32766E-01	2.99556E-02	1.00000E+00
11	0.	0.	2.65786E-01	1.70395E+00	2.02278E-01	4.06132E-02	2.28947E-02	1.00000E+00
12	0.	0.	2.13067E-01	1.50525E+00	1.51602E-01	4.09681E-02	2.04972E-02	1.00000E+00
13	0.	0.	2.08592E-01	7.18469E-01	1.71299E-01	2.33369E-02	1.39556E-02	1.00000E+00
14	0.	0.	2.31416E-01	8.93660E-01	1.91416E-01	2.13955E-02	1.86039E-02	1.00000E+00
15	0.	0.	1.49278E-01	1.35697E+00	1.01047E-01	2.56072E-02	2.26232E-02	1.00000E+00
16	0.	0.	4.20092E-02	4.02670E-01	2.67222E-02	8.56323E-03	6.72374E-03	1.00000E+00
17	0.	1.00000E+00	6.50833E+00	4.29442E+01	6.50832E+00	6.82929E-01	3.17081E-01	1.00000E+00

GRP.	RT BDY FLUX	RT BDY J+	RT BDY J	RT LEAKAGE	LFT LEAKAGE	FISS RATE	TOTAL FLUX	DENSITY
1	2.85430E-05	2.14217E-05	2.14217E-05	5.88188E-03	0.	7.70221E-03	3.89337E+00	3.89337E+00
2	1.10278E-04	7.44024E-05	7.44024E-05	2.04290E-02	0.	1.95547E-02	1.15054E+01	1.15054E+01
3	6.51196E-05	4.04443E-05	4.04443E-05	1.11050E-02	0.	1.28841E-02	8.48004E+00	8.48004E+00
4	9.24738E-05	5.51745E-05	5.51745E-05	1.51496E-02	0.	1.72985E-02	1.24283E+01	1.24283E+01
5	1.29465E-04	7.66237E-05	7.66237E-05	2.10390E-02	0.	2.86745E-02	1.78961E+01	1.78961E+01
6	1.70888E-04	1.00123E-04	1.00123E-04	2.74913E-02	0.	5.75751E-02	2.30772E+01	2.30772E+01
7	8.90265E-05	5.21760E-05	5.21760E-05	1.43262E-02	0.	4.56122E-02	1.01777E+01	1.01777E+01
8	2.17340E-04	1.27091E-04	1.27091E-04	3.48962E-02	0.	1.37080E-01	1.95748E+01	1.95748E+01
9	1.96765E-04	1.14753E-04	1.14753E-04	3.15083E-02	0.	1.90271E-01	1.23274E+01	1.23274E+01
10	1.87624E-04	1.09098E-04	1.09098E-04	2.99556E-02	0.	1.89917E-01	7.33068E+00	7.33068E+00
11	1.43760E-04	8.33824E-05	8.33824E-05	2.28947E-02	0.	5.10736E-02	3.77023E+00	3.77023E+00
12	1.29033E-04	7.46508E-05	7.46508E-05	2.04972E-02	0.	7.98864E-02	3.09263E+00	3.09263E+00
13	8.79909E-05	5.08262E-05	5.08262E-05	1.39556E-02	0.	4.34967E-02	1.47858E+00	1.47858E+00
14	1.17439E-04	6.77551E-05	6.77551E-05	1.86039E-02	0.	3.93949E-02	1.74051E+00	1.74051E+00
15	1.42988E-04	8.23936E-05	8.23936E-05	2.26232E-02	0.	4.50217E-02	2.10571E+00	2.10571E+00
16	4.25003E-05	2.44878E-05	2.44878E-05	6.72374E-03	0.	1.37230E-02	6.08222E-01	6.08222E-01
17	1.95121E-03	1.15480E-03	1.15480E-03	3.17081E-01	0.	9.79166E-01	1.39487E+02	1.39487E+02

MATERIAL BUCKLING 1.85032E-03

THIS PROBLEM REQUIRED 125.84 SECONDS

TABLE 2-5

CONTENTS OF ANISN-W PROGRAM GENERATED TAPE 17

RECORD	CONTENTS
1	IGM, ID, IGE, IM, IP, EV, IZM, (T(I), I = 1, 8), selected integer data, radii and fission density. (RA(I), FD(I), MA*I), I = 1, IM), RA(IP)
2	Total Flux (One Record Per Group)
.	. .
.	. .
IGM + 1	. .
2 + IGM	Integer Input Data, 15$ Array
3 + IGM	Floating Point Input Data, 16* Array
4 + IGM	Material Numbers by Zone, 9$ Array
5 + IGM	Zone Numbers by Interval, 8$ Array
6 + IGM	Fission Spectrum by Group, 1* Array
7 + IGM	Quadrature Weights, 6* Array
8 + IGM	Quadrature Direction Cosines, 7* Array
9 + IGM	Reflective Direction Indices
10 + IGM	Radii by Interval
11 + IGM	Volumes by Interval
12 + IGM	Nu*Sigma Fission Cross Section for Group 1, All Materials
13 + IGM	Total Cross Section for Group 1, All Materials
.	Nu*Sigma Fission Cross Section for Group 2, All Materials
.	Total Cross Section for Group 2, All Materials
.	. . .
.	. . .
13 + 3* IGM	Angular Flux at Each Mesh Line for Group 1
.	. . .
.	. . .
.	. . .
13 + 4* IGM	Angular Flux at Each Mesh Line for Group IGM

2.6 PROGRAM LOGIC

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

2.6.1 Subroutine Description

Table 2-6 briefly describes the principal function of each subroutine in the ANISN-W code. This table is included so that the user can familiarize himself with respect to the various types of calculations performed by the ANISN-W code.

2.6.2 Calculational Procedure

The simplified, flow chart of the major calculations performed by the ANISN-W code is shown in Figure 2-2. For clarity, only the principal calculational routines are shown; the other routines are straightforward calculations or operations.

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

The level structure used in the overlay of the ANISN-W code is shown in Figure 2-3. Levels are used to describe the sequence of loading overlays and to specify which sections of the source program overlay others. The main level of the overlay structure always resides in core storage. Only one primary level and its respective secondary levels can reside in core storage at one time.

An increase of approximately $15,000_{10}$ core storage locations for ANISN-W problem data resulting in a total problem data storage of $49,000_{10}$ is achieved using the OVERLAY feature of the MSFC UNIVAC-1108 computer.

TABLE 2-6

LIST OF ANISN-W CODE SUBROUTINES AND THEIR PRINCIPAL OPERATION

Subroutine Name	Principal Operation
ANISN	Sets up and zeros out blank common storage
CONTRL	Overall control of program information flow
ERRO	Prints error messages
WOT	General print routine
PLSNT	Variable dimension and input data read control
FIDO	Generalized input data read routine
TP	Reads cross sections, source, flux, or fission guess data
ADJNT	Performs adjoint reversals of selected data arrays
S805	Performs adjoint reversals of cross section data
S804	Checks S_n constants and computes P_l constants
S814	Computes areas, volumes, and total fixed source
WOT8	General print routine
S966	Reads cross section library tape
GUTS	Controls iteration loops
S807	Mixes cross sections
S810	Computes geometry dependent arrays
S824	Computes total source by interval
S821	Computes and normalizes fission source and normalizes fluxes
DT	Inner iteration diffusion theory calculation
S833	Inner iteration transport theory calculation
S851	Outer iteration convergence tests and new eigenvalue computations for search calculations
FINPR1	Storage allocation for activities and cross section weighting

TABLE 2-6 (CONTINUED)

LIST OF ANISN-W CODE SUBROUTINES AND THEIR PRINCIPAL OPERATION

Subroutine	Principal Operation
FINPR	Computes activities and printout of results
PUNSH	Controls card punching
DTFPUN	Specialized punch routine
FLTFX	Specialized punch routine
BT	Storage allocation for balance tables
WRITE	Writes output data on tape 17 for subsequent analyses
SUMMARY	Balance table computation and printout
FEWG	Preliminary calculations for cross section weighting
WATE	Cross section weighting calculation and printout
SECOND	Computes CPU (Central Processor Unit) time in seconds

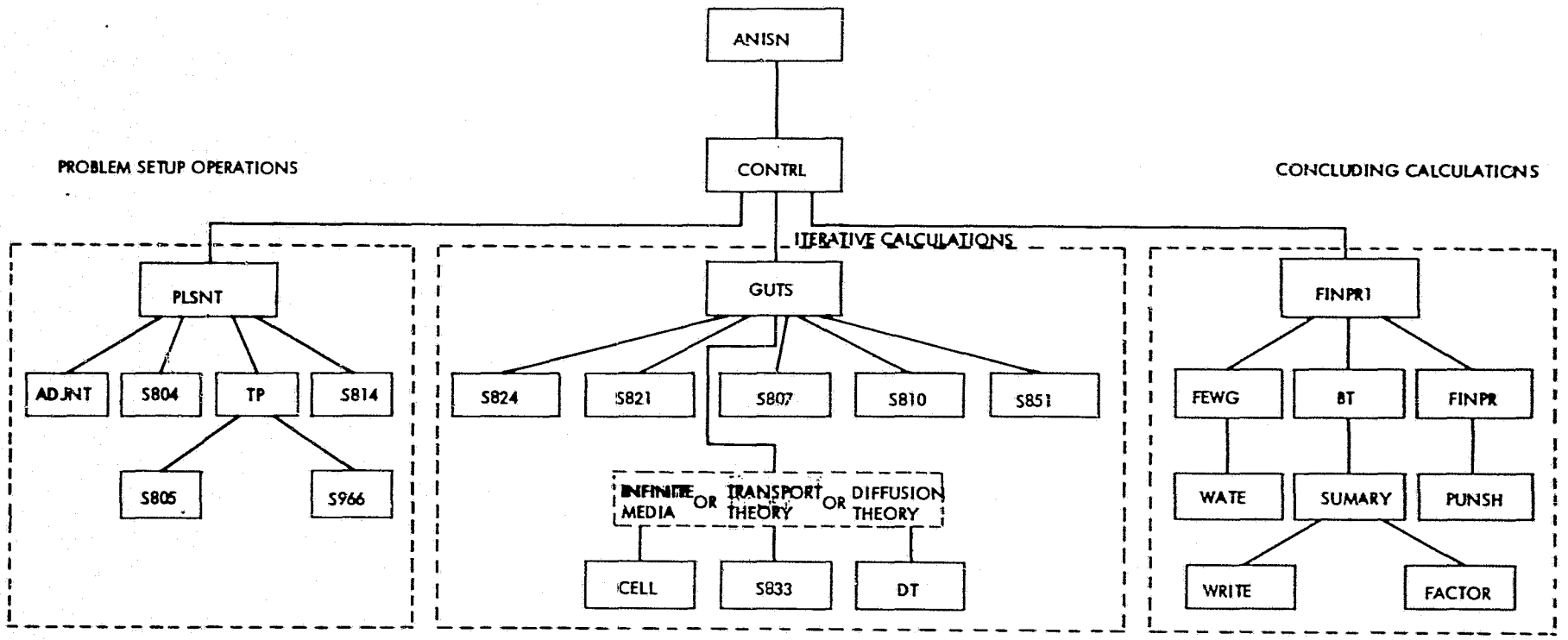

Figure 2-2. Flow Chart for the ANISN-W Code

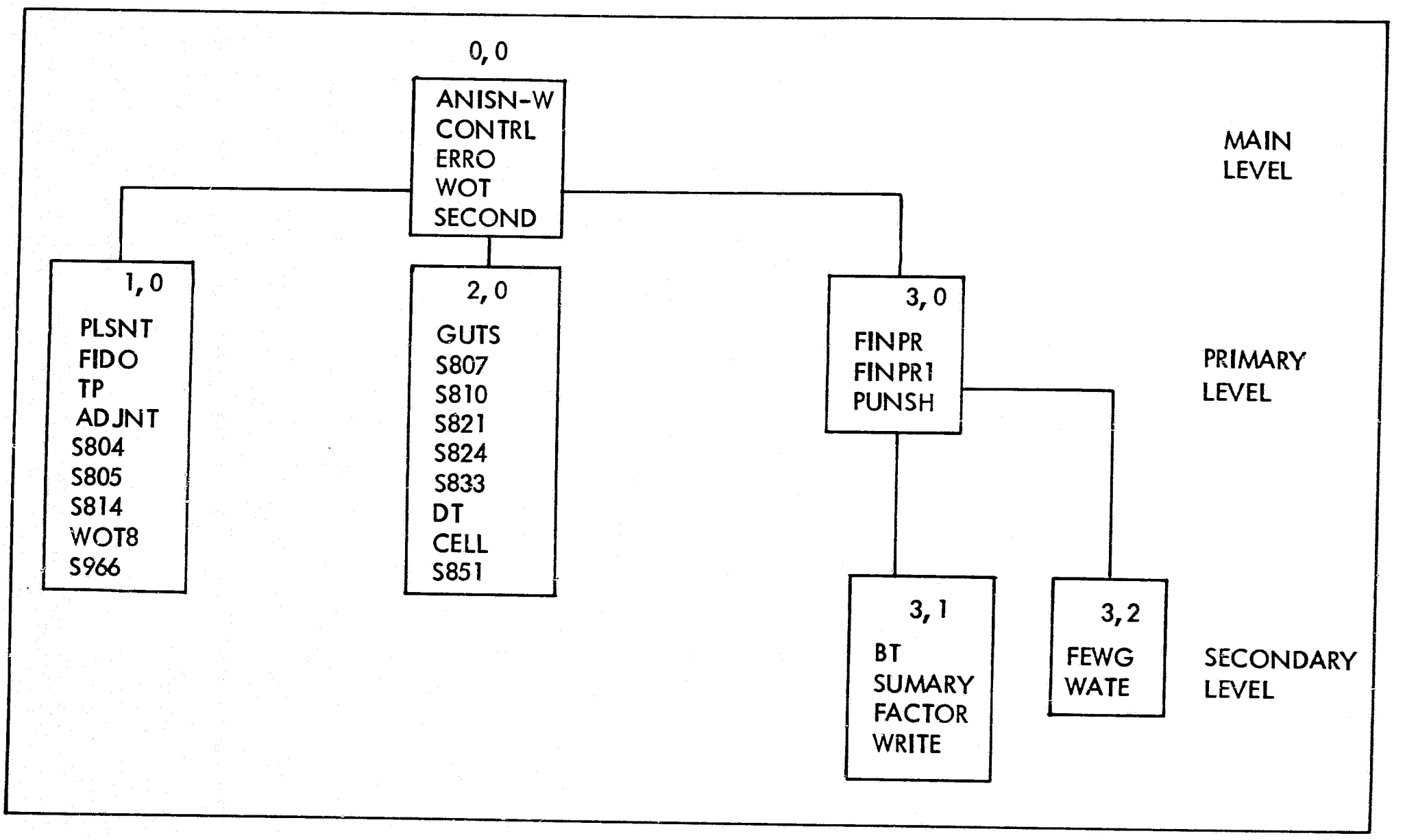

Figure 2-3. Overlay Structure for the ANISN-W Code

2.7 METHOD OF SOLUTION

In many ways, the ANISN-W program is similar to the DTF-IV code in the method of solution. For this reason, the user is referred to Reference 4 where detailed equations are given describing the discrete ordinates transport solution of the Boltzmann transport equation. References 9 and 10 also contain pertinent information.

3.0 REFERENCES

1. W. W. Engle, Jr., "A User's Manual For ANISN, A One-Dimensional Discrete Ordinates Transport Code With Anisotropic Scattering," K-1693, March 30, 1967.

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

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

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

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