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MATHEMATICS DIVISION

SWANLAKE, A COMPUTER CODE UTILIZING ANISN RADIATION TRANSPORT CALCULATIONS FOR CROSS SECTION SENSITIVITY ANALYSIS

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ABSTRACT

SWANLAKE calculates the sensitivity of a result (such as a dose or reaction rate) obtained from a one-dimensional discrete ordinates solution of the Boltzmann transport equation to the cross sections used in the calculation. This manual presents a brief discussion of the sensitivity function and the method used for its calculation, detailed instructions concerning the required input data, and a description of the code output. As an aid to the prospective user, the input and output of a sample problem are included, along with an interpretation of the results. A derivation of the sensitivity function and a listing of computing time and core requirements for several problems are included as appendices.

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COMPUTER CODE ABSTRACT

1. NAME AND TITLE OF CODE

SWANLAKE: Cross Section Sensitivity Analysis Code for One-Dimensional Discrete Ordinates Calculations.

AUXILIARY ROUTINES

ANISN: Input Tape Generator.

INTRIGUE-III: CALCOMP Plotting Package.

2. CODING LANGUAGE AND COMPUTER

FORTRAN IV: IBM 360/91.

3. NATURE OF PROBLEM SOLVED

Determination of the sensitivity of a calculated quantity or result to microscopic cross section data utilized in the calculation.

4. METHOD OF SOLUTION

A particular sensitivity function, which represents an application of earlier perturbation approaches, is determined for the cross sections which were utilized in the discrete ordinates calculation. The sensitivity of a result, R, to a particular cross section, X, at energy E may be expressed as:

$$P_X(E) = \frac{\left[\int_{\vec{r}} dr \int_{\vec{\Omega}} d\Omega \; \rho_X(\vec{r}) \left\{ -\Phi^*(\vec{r},\vec{\Omega},E)\sigma_{X_T}(E)\Phi(\vec{r},\vec{\Omega}E) + \int_{\vec{\Omega}'} d\Omega' \int_{E'} dE'\Phi^*(\vec{r},\vec{\Omega},E')\sigma_X(\vec{\Omega}\cdot\vec{\Omega}'E\to E')\Phi(\vec{r},\vec{\Omega},E)\right\}\right]}{R} \qquad (1)$$

where $\Phi^*(\vec{r},\vec{\Omega},E)$ is the unperturbed adjoint flux,

$\Phi(\vec{r},\vec{\Omega},E)$ is the unperturbed forward flux,

$\sigma_{X_T}(E)$ is the total cross section for reaction type X,

$\sigma_X(\vec{\Omega}\cdot\vec{\Omega}',E\rightarrow E')$ is the scattering cross section from angle $\vec{\Omega}$ to $\vec{\Omega}'$, energy E to E', for reaction type X,

$\rho_X(\vec{r})$ is the atomic number density,

and R is the integrated response,

$$R = \int_{\vec{r}} d\vec{r} \int_{\vec{\Omega}} d\Omega \int_E dE\ D(\vec{r},\vec{\Omega},E)\Phi(\vec{r},\vec{\Omega},E), \tag{2}$$

with $D(\vec{r},\vec{\Omega},E)$ the response function, for example a flux-to-dose conversion factor, and is the source for the adjoint calculation of $\Phi^*(\vec{r},\vec{\Omega},E)$.

All the above quantities are defined for the specific problem under consideration, and X may refer to partial cross sections such as elastic or inelastic as well as to the total collision cross sections. (For an absorption reaction, there would be no scattering term.) The domain of $\vec{r}$ may be specified as all space or may be restricted to a given spatial zone in order to examine sensitivity as a function of space.

The quantities of $\Phi(\vec{r},\vec{\Omega},E)$ and $\Phi^*(\vec{r},\vec{\Omega},E)$ are read from angular flux tapes generated in forward and adjoint calculations, respectively, of the problem of interest.

5. RESTRICTION OR LIMITATIONS

The discrete ordinates calculations to be analyzed by this version of SWANLAKE must be time-independent and one-dimensional. The sensitivity function only allows for energy downscatter, does not include the effects of fission cross sections, and cannot evaluate the sensitivity of the calculated quantity or response to the response function itself.

6. TYPICAL RUNNING TIME

The infinite air sample problem included in the code package required 2.5 minutes for the ANISN forward calculation, 2.5 minutes for the ANISN adjoint calculation, and 1.8 minutes for the SWANLAKE calculation. Running time for both ANISN and SWANLAKE is highly problem dependent and is greatly affected by parameters such as the number of energy groups and the number of spatial intervals utilized.

7. COMPUTER HARDWARE REQUIREMENTS

Designed for the IBM 360/91, SWANLAKE is also operable on the 360/75. Maximum core requirement for the sample problems discussed in the code manual is 848k bytes, minimum size is 290k bytes.

Auxiliary storage requirements, in addition to standard input and output devices, are 2 scratch devices and 3 storage devices. If cross sections are not read in from cards, an additional tape or disk will be required, and if the CALCOMP plotting routine included in the package is to be utilized, another tape is required.

8. COMPUTER SOFTWARE REQUIREMENTS

The code is written in FORTRAN IV and is operable on the standard IBM 360 compilers.

9. REFERENCES

D. E. Bartine, F. R. Mynatt, and E. Oblow, "SWANLAKE, A Computer Code Utilizing ANISN Transport Calculations for Cross Section Sensitivity Analysis," ORNL-TM-3809 (1973).

W. W. Engle, Jr., "A User's Manual for ANISN, A One-Dimensional Discrete Ordinates Transport Code with Anisotropic Scattering," K-1693 (March 1967).

M. B. Emmett, "INTRIGUE-II: An IBM 360 Subroutine Package for Making Linear, Logarithmic and Semilogarithmic Graphs Using the CALCOMP Plotter," ORNL-4664 (March 1971).

10. CONTENTS OF CODE PACKAGE

The package contains the following items:

a. the referenced documents,

b. a reel of magnetic tape on which is written in several files: the source card deck, input for a sample problem and output listing for SWANLAKE, ANISN problems and output, and INTRIGUE-IIL plotting package.

11. HOW TO OBTAIN PACKAGE

Inquiries or requests for the code package may be mailed to

CODES COORDINATOR
Radiation Shielding Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37830

or telephoned to

Area Code 615; 483-8611, extension 3-6944, or to

FTS xx-615-483-6944.

Persons requesting the package should send a reel of magnetic tape to the above address.

I. AN INTRODUCTION TO CROSS SECTION SENSITIVITY ANALYSIS

A. Definition of a Sensitivity Function

Cross section sensitivity analysis refers to a determination of how sensitive a calculated quantity or result is to microscopic cross section data utilized in the calculation. Previous work in this field has employed both direct substitution methods[1-4] and perturbation theory.[5-7] The sensitivity function used in the work reported here represents an application of earlier perturbation approaches. The sensitivity of a result or effect of interest, R, to a particular cross section, X, at energy E may be expressed as:

$$P_X(E) = \frac{\left[\int_{\vec{r}} dr \int_{\vec{\Omega}} d\Omega \, \rho_X(\vec{r}) \left\{ -\Phi^*(\vec{r},\vec{\Omega},E)\sigma_{X_T}(E)\Phi(\vec{r},\vec{\Omega}E) + \int_{\vec{\Omega}'} d\Omega' \int_{E'} dE' \Phi^*(\vec{r},\vec{\Omega},E')\sigma_X(\vec{\Omega}\cdot\vec{\Omega}' E\to E')\Phi(\vec{r},\vec{\Omega},E) \right\}\right]}{R} \tag{1}$$

where

$\Phi^*(\vec{r},\vec{\Omega},E)$ is the unperturbed adjoint flux,

$\Phi(\vec{r},\vec{\Omega},E)$ is the unperturbed forward flux,

$\sigma_{X_T}(E)$ is the total cross section for reaction type X,

$\sigma_X(\vec{\Omega}\cdot\vec{\Omega}',E\to E')$ is the scattering cross section from angle $\vec{\Omega}$ to $\vec{\Omega}'$, energy E to E', for reaction type X,

$\rho_X(\vec{r})$ is the atomic number density,

and R is the integrated response,

$$R = \int_{\vec{r}} d\vec{r} \int_{\vec{\Omega}} d\Omega \int_{E} dE \; D(\vec{r},\vec{\Omega},E)\Phi(\vec{r},\vec{\Omega},E), \tag{2}$$

with $D(\vec{r},\vec{\Omega},E)$ the response function, for example a flux-to-dose conversion factor, and is the source for the adjoint calculation of $\Phi^*(\vec{r},\vec{\Omega},E)$.

All the above quantities are defined for the specific problem under consideration, and X may refer to partial cross sections such as elastic or inelastic as well as to the total collision cross sections. (For an absorption reaction, there would be no scattering term.) The domain of $\vec{r}$ may be specified as all space or may be restricted to a given spatial zone in order to examine sensitivity as a function of space. A derivation of the sensitivity function is presented as Appendix A, and a discussion of the theoretical background of this representation is available as a separate report.[8]

B. Discrete Ordinates Sensitivity Formulation

The solution of the time-independent Boltzmann transport equation by discrete ordinates methods has been documented[9,10] and will not be repeated here. However, a brief discussion of this approach will allow a clear presentation of the discrete ordinates form for Eq. (1). In one-dimensional discrete ordinates formulation, the spatial variation and energy dependence of the flux is divided into INT spatial intervals and IGM energy groups. The angular flux for interval J and group I is determined from results of an ANISN[11] calculation as

$$\Phi(J,\vec{\Omega},I) = \left[\Phi_j^I(\vec{\Omega}) + \Phi_{j-1}^I(\vec{\Omega})\right]/2 \tag{3}$$

where $\Phi_j^I(\vec{\Omega})$ is the ANISN angular flux for energy group I at spatial interval boundary j. The angular variation of the flux is represented by NOA discrete angles and the integral of the flux over angle may be replaced by a Gaussian quadrature formula so that the flux for interval J, angle K, and group I is expressed as

$$\Phi(J,K,I)\ WT(K) = \int_{\Delta\vec{\Omega}_K} d\Omega\ \Phi(J,\vec{\Omega},I), \tag{4}$$

where

$\Phi(J,K,I) = \Phi(J,\vec{\Omega}_K,I)$

= flux for interval J, group I, at the discrete angle $\vec{\Omega}_K$,

$WT(K)$ = weight given to flux at angle $\vec{\Omega}_K$ in the Gaussian quadrature.

The angular dependence of the cross sections is expressed as an (ℓ_{max+1}) term Legendre series expansion in μ, the cosine of the scattering angle. SWANLAKE handles the Legendre expansion correctly for slab, spherical or cylindrical geometry, but only the slab or spherical case will be presented here. The ℓth moment of the scattering cross section from energy group I to I' is then

$$\sigma_X^\ell(I\to I') = 2\pi\left(\frac{2\ell+1}{2}\right)\int_{-1}^{+1} d\mu\ \sigma_X(\vec{\Omega}\cdot\vec{\Omega}',I\to I')\ P^\ell(\mu), \tag{5}$$

where $P^\ell(\mu)$ is the Legendre function.

The ℓth moment of the flux can be represented by

$$\Phi^\ell(J,I) = \sum_{K=1}^{NOA} \Phi(J,K,I)\ WT(K)\ P^\ell(K). \tag{6}$$

Using the preceding formulations and dividing the spatial integration into NZONE spatial zones, the multigroup discrete-ordinates form for the sensitivity function in Eq. (1) becomes

$$P_X(I) = \left[\frac{\displaystyle\sum_{IZ=1}^{NZONE} \rho_X(IZ) \sum_{J=IZI}^{IZF} VOL(J) \left\{ -\sum_{K=1}^{NOA} \Phi^*(J,K,I)\sigma_{X_T}(I) \, \Phi(J,K,I)\, WT(K) + \sum_{\ell=0}^{\ell max} \sum_{I'=I}^{IGM} \Phi^{*\ell}(J,I')\, \sigma_X^\ell(I \to I')\, \Phi^\ell(J,I) \right\}}{\left[\displaystyle\sum_{J=1}^{INT} \sum_{\ell=0}^{\ell max} \sum_{I=1}^{IGM} D^\ell(J,I)\, \Phi^\ell(J,I) \right]} \right], \tag{7}$$

where

$\rho_X(IZ)$ is the number density for cross section X in spatial zone IZ,

IZI is the initial spatial interval in spatial zone IZ,

IZF is the final spatial interval in spatial zone IZ,

VOL(J) is the volume of interval J.

This equation represents the basic calculation performed in SWANLAKE. In practice, however, Eq. (7) is calculated as a product of the density, the cross section matrix, and a matrix containing multiples of the forward and adjoint flux which is referred to as the $\Phi^*\Phi$ matrix. First rearrange Eq. (7) to give

$$P_X(I) = \sum_{IZ=1}^{NZONE} \rho_X(IZ) \left[- \sigma_{X_T}(I) \sum_{J=IZI}^{IZF} VOL(J) \sum_{K=1}^{NOA} \Phi^*(J,K,I)\Phi(J,K,I)WT(K) \right. \tag{8}$$

$$\left. + \sum_{\ell=0}^{\ell max} \sum_{I'=1}^{IGM} \sigma_X^\ell(I \to I') \sum_{J=IZI}^{IZF} \Phi^{*\ell}(J,I')\Phi^\ell(J,I) \right] /R,$$

$$\text{where } R = \sum_{J=1}^{INT} \sum_{\ell=0}^{\ell max} \sum_{I=1}^{IGM} D^\ell(J,I)\Phi^\ell(J,I).$$

Now express (8) as

$$P_X(I) = \sum_{IZ=1}^{NZONE} \rho_X(IZ) \left[- \sigma_{X_T}(I) \; Z^{\ell=0}(3,I) \right. \tag{9}$$

$$\left. + \sum_{\ell=0}^{\ell max} \sum_{I'=I}^{IGM} \sigma_X^\ell(I \to I') \; Z^\ell(4+I'-I,I) \right] /R,$$

where Z is the $\Phi^*\Phi$ matrix and corresponds to the format of the cross section matrix for ANISN, in which $\ell = 0$, position 3, I contains the total cross section for group I, position 4 contains the within group cross section for group I, and subsequent positions contain the down-scattering cross sections from group I' to group I. This separation has the advantage that the $\Phi^*\Phi$ matrix need only be calculated once, since it is a function of the forward and adjoint solutions, and will be the same for all cross section sets used in the calculation of the problems under investigation.

C. Applications of the Sensitivity Function

The sensitivity definition of Eq. (7) has been found to be convenient for identification of the most important cross sections for a given problem in terms of element, isotope, and specific reaction cross sections.

A plot of the sensitivity function vs energy is referred to as a sensitivity profile, and indicates cross section importance as a function of the energy of the incident particle. This "fingerprint" of the calculation has many potential uses since it quantitatively focuses attention on the important cross section data. These uses include an indication of the need for specific cross section evaluation and measurements, the correlation of integral experiments and design problems, and the prediction of overall uncertainty in a design problem.

Equation (7) can be integrated over the incident energy E to give the total sensitivity of the problem to the cross sections for specific reaction types. For example, the effect of Legendre series truncation for a multigroup σ^{ℓ} cross section set may be evaluated by examining sensitivity as a function of the number of expansion terms. Information regarding the variation of cross section importance as a function of space may also be obtained by breaking up the spatial integration into zones.

II. SWANLAKE

A. Calculational Outline

Basically, SWANLAKE takes the forward and adjoint angular flux solutions for a given problem and combines them with the cross section to be studied according to Eq. (7). Sensitivities are obtained for each cross section set as a function of spatial zone and summed over zone. A sum over all cross section sets input for analysis is also calculated for each zone and over all zones. The resulting sensitivities by energy group are divided by the lethargy interval per group in an attempt to remove the dependence on the multigroup structure, and are then plotted as a function of energy.

The principle subroutines in SWANLAKE function as follows:

MAIN - sets blank common size;

CONTRL - sets addresses in blank common, reads input, calls calculational subroutines;

ADTAPE - reorders adjoint angular flux tape;

PERT - calculates $\psi^{*}\psi$ matrix;

RESULT - calculates sensitivity for given cross section set;

DRAW - plots sensitivity per unit lethargy vs particle energy in MeV.

B. General Requirements

The primary requirement is that the transport problem be properly stated in that the forward and adjoint calculations give the same result. For the forward calculation, as given in Eq. (2)

$$R = \int_{\vec{r}} dr \int_{\vec{\Omega}} d\Omega \int_{E} dE \; D(\vec{r},\vec{\Omega},E) \Phi(\vec{r},\vec{\Omega},E),$$

and for the adjoint calculation

$$R = \int_{\vec{r}} dr \int_{\vec{\Omega}} d\Omega \int_{E} dE \; S(\vec{r},\vec{\Omega},E) \; \Phi^{*}(\vec{r},\vec{\Omega},E), \tag{10}$$

where $D(\vec{r},\vec{\Omega},E)$ is the response function for the forward calculation and the source for the adjoint calculation,

and $S(\vec{r},\vec{\Omega},E)$ is the source for the forward calculation and the response function for the adjoint calculation.

Obtaining consistent agreement for R might require a higher order angular quadrature and a finer spatial mesh than would normally be used for the calculation. Care must also be taken to express the source and response functions in a consistent set of units for SWANLAKE. The user should refer to Appendix C for details.

The logical numbers required for input-output files and their uses are:

logical 1. forward angular flux;

logical 2. adjoint angular flux;

logical 3. scratch device;

logical 4. scratch device;

logical 5. standard input;

logical 6. standard output;

logical 7. $\Phi^{*}\Phi$ matrix by zone;

logical 8. cross sections if not from cards;

logical 45. calcomp plot tape.

While the current version of SWANLAKE is applicable to a wide range of problems, some limitations should be noted. Problems must be time-independent and one-dimensional. The present sensitivity function only allows for energy downscatter, does not include the effects of fission cross sections, and cannot evaluate the sensitivity of the calculated response to the response function. It is anticipated that most, if not all, of the above restrictions will be removed in future versions.

Users who do not wish to use the included INTRIGUE-II-L[12] calcomp plotting package may remove logical 45. and the following subroutines: SEEK, HOLLER, SUBVAL, EXPON, GRECO, LETTER, RS, SUBTLE, TENS, VALUE, XTENS, YS, ADVANC, CURVE, DDASH, LINEAR, LOGLOG, MBE, POINT, SEMLOG, GREEK. If these subroutines are removed, DRAW must be shortened as indicated by the comment cards in that subroutine, or a change must be made in JCL so that a run is permitted to continue. The JCL included with SWANLAKE are for the Oak Ridge National Laboratory IBM 360/91, and are given as an illustration, as are the DD cards for the logical units used in the sample problem.

C. Input

This section is intended to be used as a guide in preparing problems for SWANLAKE. Data may be input in either conventional FIDO ($ or *) or free-form ($$ or **) format[13] in the order listed. ($ units call for fixed point or integer input and * units require floating point input.) Calculational options determine which input sets are required. A brief explanation will be included with each input item, along with examples as required. The bracketed numbers refer to the number of entries required for each unit. Normal FIDO shorthand such as F for fill, R for repeat, etc. are allowed. Note the placement of the T required at the end of each input set. Since blank common and total core requirements are determined by input parameters used in the sensitivity calculation, they will be presented after the input description.

1$$ [16]

(1)	IGM	number of energy groups
(2)	ITL	cross section table length (present version requires this to be IGM+3 or less)
(3)	INT	number of spatial intervals
(4)	ISN	order of S_n
(5)	ISCT	order of cross section expansion
(6)	NZONE	number of spatial zones
(7)	NE	number of cross section sets
(8)	ITAPE	(1/2), (calculate/read from logical 7.) $\phi^*\phi$ matrix (once $\phi^*\phi$ matrix is calculated, it is stored on logical 7. as a function of spatial zone, and is therefore available for analysis of additional cross section sets)
(9)	ISIG	(1/2), cross sections from (cards/tape)
(10)	IGOM	(1/2/3), (plane/cylindrical/sphere) geometry
(11)	IPRNT	(0/1), (don't print/print) cross sections
(12)	IPLZN	(0/1), (don't print/print) P_ℓ predictions and full P_ℓ sensitivity matrix

(13) IARNG (1/2/3), sensitivity matrix in (ANISN/MORSE[14]/both) format (for a given energy group I, ANISN prints σ_T in position 3, then I'→I, while MORSE prints σ_T in position 3, then I→I')

(14) IPLOT (0/1/2/3) plot sensitivity profiles (none/for neutron cross sections/for gamma cross sections/for both) summed over all spatial zones

(15) IPLTZ (0/1), (don't plot/plot) sensitivity profiles for each separate spatial zone

(16) ILNG last energy group for first particle type (normally last neutron group)

2* [1]

RTOTAL integrated response, R, for the problem investigated

T--

4*, 5*, 6*, and 7$ data are required if ITAPE = 1.

If ITAPE = 2, the next input will be neutron energy group boundaries, (8*).

4* [NOA]† S_n weights

5* [NOA] S_n cosines

T

6* [INT+1] interval boundaries

7$ [NZONE+1] numbers of interval boundaries corresponding to zone boundaries

T--

† NOA = ISN+1 for plane or sphere

NOA = (ISNx(ISN+4))/4 for cylinder

8* [ILNG] neutron energy group boundaries in MeV, high to low

9* [IGM-ILNG+1] gamma energy group boundaries in MeV, high to low

T

The following data, (title cards, 10$, 11* or 11$, and 12*), must be repeated for each cross section set to be analyzed (INE = 1 to NE).

Title card for cross section set INE (20A4 format).

Title card for gamma sensitivity profile plot (20A4 format), only input if IPLOT = 3.

NOTE: The first title appears at the beginning of the sensitivity analysis output and on the plot for the first particle type. The second title appears on the second plot.

10$ [1] order of P_n for cross-section set INE (this number is carried as the variable LISN)

T

11* [IGMxITLx(LISN+1)] cross section set INE input on cards (ISIG = 1)

T

or

11$ [LISN+1] library ID numbers for cross section set INE to be input from logical unit 8 (ISIG = 2)

T

12* [NZONE] number density by spatial zone for cross section set INE

T

If NE > 1, title card for neutron summation plot.

If NE > 1 and IPLOT = 3, title card for gamma summation plot.

Blank common requirements are specified on two cards in the MAIN routine of SWANLAKE:

Card (1) COMMON D(XXXXXX)

Card (2) JBLCOM = XXXXXX

where XXXXXX specifies the blank common requirement in words. Two different blank common requirements are possible. If ITAPE = 1, set blank common to maximum value, (A) or (B). If ITAPE = 2, set blank common to (B). The underlined portions of the equations are usually the dominant factors in determining the space required, and the following definitions are employed:

LLN = 40 if IPLOT = 3
= 20 otherwise;

NOA = ISN+1 for slab and sphere
= [(ISN)(ISN+4)]/4 for cylinder;

LMOM1 = ISCT+1 for slab and sphere
= 1 + [(ISCT)(ISCT+4)]/4 for cylinder;

ITT = the maximum number of spatial intervals in any spatial zone.

$$\text{(A)}\quad 90 + (\text{LLN})(\text{NE}+1) + \underline{[5 + \text{LMOM1} + (2)(\text{INT})]\ [\text{NOA}]}$$
$$+ \underline{[(\text{ITL})(\text{IGM}) + (\text{ITT})(\text{IGM}+1)]\ [\text{LMOM1}]} + \text{IGM} + \text{INT} + \text{NZONE}$$

$$\text{(B)}\quad 92 + (3)(\text{NOA}) + \underline{[\text{LLN} + (\text{IGM})(\text{NZONE}+\text{ISCT}+2)]\ [\text{NE}+1]}$$
$$+ \underline{[\text{NOA} + (\text{IGM})(\text{ITL})]\ [\text{LMOM1}]} + \underline{(\text{ISCT}+2)(\text{IGM})(\text{ITL})}$$
$$+ (\text{IGM}+1)(\text{ISCT}) + \text{IGM} + \text{INT} + (2)(\text{NZONE})$$

If an insufficient blank common is specified, the code will so indicate, and the job will be terminated.

Since the spatial zones specified for the ANISN calculations can be subdivided for analysis by SWANLAKE, ITT can be made arbitrarily small, and the blank common requirements decreased. Calculational time, however, will increase in an approximately linear fashion with the number of spatial zones specified. The total core requirement is the sum of the core required for the SWANLAKE program + blank common requirements + requirements for input-output devices. Although exact requirements will vary with specific computer systems, a general idea can be obtained from the requirements for the IBM 360/91 system at Oak Ridge National Laboratory, which is roughly 30K words plus blank common requirements. Appendix B gives core and time requirements, along with a brief description of the problem being analyzed, for a variety of calculations.

The forward and adjoint angular fluxes must be input when ITAPE = 1 on logical units 1 and 2, respectively. SWANLAKE expects the forward angular fluxes to be similar to those computed by ANISN, that is, to have the same units, (particles-cm^{-2}-sec^{-1}-unit weight^{-1}), and to be in the same order. The forward angular fluxes must be in the order of group, angle, and spatial interval boundary, i.e.:

group 1, angle 1, interval boundary 1 to INT+1;
group 1, angle 2, interval boundary 1 to INT+1;
.
.
.
group 1, angle NOA, interval boundary 1 to INT+1;
group 2, angle 1, interval boundary 1 to INT+1;
.
.
.
group IGM, angle NOA, interval boundary 1 to INT+1.

The adjoint angular fluxes are also expected to be in the order of group, angle, and interval boundary. The interval boundary specification remains the same, (1 to INT+1), but the energy group order is inverted (low to high). For slab and spherical geometry, (IGOM = 1, 3), the angular order is the inverse of the forward case (NOA to 1). For cylindrical geometry, (IGOM = 2), the angles are listed in the order of the reflected direction specified in the output from the ANISN adjoint calculation. Subroutine ADTAPE reorders the adjoint angular flux to correspond to the forward angular flux, but does not rewrite logical unit 2. The forward and adjoint angular fluxes required on logical units 1 and 2 in SWANLAKE may be obtained by specifying logical units 1 and 2 for the forward and adjoint ANISN calculations. An output device must be specified for both units 1 and 2 for both the forward and adjoint ANISN calculations. The ANISN output will specify which logical unit contains the angular fluxes. Experience has shown that for the Oak Ridge system, the forward angular flux is usually written on logical 1, while the adjoint angular flux is usually written on logical 2.

D. Output

This section lists the output in the order in which it would appear as the result of a SWANLAKE calculation. Where an output section is optional, the input parameter designating inclusion of this output is indicated. In general, the output begins with a printout of input quantities for diagnostic and identification purposes. Next an analysis of the problem sensitivity is presented for each cross section set, followed by an analysis for the sum of the individual sets. The energy group structure utilized for this problem is then given, followed by the sensitivity per unit lethargy by energy group for each cross section set and for the sum of the individual sensitivities. The number of entries in each output section is indicated by brackets.

1. Printout of input quantities

a.	[1]	number of words requested for blank common
b.	[20]	1$$ input parameters, in order, with explanations for each entry, followed by the total response determined by the transport calculation
c.	[(3)(NOA)]	reflected directions as a function of angle, Gaussian quadrature weights as a function of angle, and cosines as a function of angle
d.	[(NOA)(ISN+1)]	Legendre coefficients for flux expansion as a function of angle and moment
e.	[1]	maximum number of intervals in any spatial zone (it is necessary for the user to determine this value in order to set blank common requirements - the number printed here is ITT as determined by the code, and is included for diagnostic purposes)
f.	[1]	words of blank common required for $\Phi^*\Phi$ matrix calculation (code's computation of blank common requirement A)
g.	[INT+1]	spatial interval boundaries in cm

h. [NZONE+1] — I.D. numbers for interval boundaries serving as zone boundaries

i. [1] — words of blank common required for sensitivity calculation with full cross section expansion (code's computation of blank common requirement B)

NOTE: Items c through h above are printed out only if ITAPE = 1.

2. Sensitivity analysis information for cross section set number INE (this block is repeated NE1[†] times, where NE cross section sets are input, and NE1 is the sum of the individual sensitivities)

a. [1] — title for analysis of problem sensitivity to cross section set INE (or to sum of sensitivities if INE = NE+1)

b. [(ITL)(IGM)(LISN+1)] — cross sections for set INE, printed out if IPRNT = 1

c. [1] — number density for cross section set INE

NOTE: b and c not printed when INE = NE+1

d. [LISN] — predicted percent change in result, R, caused by decreasing Legendre expansion of cross section set INE from LISN to ℓ, ℓ = LISN-1, . . . $\ell = 0$ (printed out for all INE when IPLZN = 1 and LISN > 0)

---

† NE1 = NE+1

NOTE: c, and d if IPLZN = 1, are repeated for each zone, 1 through NZONE, followed by d for the entire system (sum of all spatial zones)

e. [(IGM)(LISN)] predicted percent change in result, R, caused by decreasing Legendre expansion of cross section set IHE from LISN+1 terms to L terms, L = LISN to 1, given as function of group for the entire system (sum of all spatial zones), printed if IPLZN = 1

f. [(ITL)(IGM)(LISN)] full sensitivity matrix, giving the problem sensitivity to each position in the cross section matrix, printed if LISN for set IHE > 0 and IPLZN = 1

g. [(ITL)(IGM)] sensitivity matrix giving each cross section position but summed over the Legendre expansion coefficients

NOTE: If IARNG = 1, f and g printed out in discrete ordinates format similar to ANISN (σ_T in position 3, then I'→I), if IARNG = 2, f and g printed out in MORSE format (σ_T in position 3, then I→I'), if IARNG = 3, f and g are printed out first in discrete ordinates format, then in MORSE format (numbers appearing in position 1 are assumed to be absorptions, so although their sensitivities are calculated correctly, they are not added to the total and downscatters to determine sensitivity by group, since absorptions are included in the Σ_T term)

h. [(IGM)(NZONE+1)] — problem sensitivity to cross section set INE as a function of energy group and spatial zone, sum over spatial zones appears as zone (NZONE+1)

i. [NZONE+1] — problem sensitivity to cross section set INE summed over energy as a function of spatial zone and particle type (sensitivities by zone printed separately for primary and secondary particles, also as sum of primary and secondary, assumed to be neutrons and gamma rays, when ILNG $<$ IGM)

3. Energy and plotting information

a. [ILNG] — energy group bounds in MeV for first particle type (normally neutrons)

b. [IGM-ILNG] — energy group bounds in MeV for second particle type (normally gamma rays)

c. [(IGM)(NZONE+1)(NE+1)] — problem sensitivity per unit lethargy as a function of energy group, spatial zone, and cross section set, zone (NZONE+1) represents a sum over spatial zones and cross section set (NE+1) represents a sum over NE individual cross section sets.

III. SAMPLE PROBLEM

A. Problem Description

The sample problem chosen for inclusion in this manual is the calculation of the total tissue dose (Snyder-Neufeld[15] for neutrons and Henderson[16] for gamma rays) resulting at 2000m in air from an unclassified thermonuclear source. A 22-18 coupled neutron-gamma cross section set for air (a macroscopic mix of microscopic nitrogen and oxygen cross sections) was used for the ANISN discrete ordinates calculations and for the sensitivity analysis. The ANISN calculations were made in spherical geometry with P_3 cross sections and an S_{40} angular quadrature. The spatial variable was divided into 169 intervals and 4 zones. The first spatial zone contains the thermonuclear source, the second zone is approximately 2000m of air, the third zone is composed of one interval at 2000m from the source, where the tissue dose response is to be determined, and the fourth zone is air extending from 2000 to 3000m, included to allow for reflection. The tissue dose computed by the forward and adjoint ANISN calculations agreed to within 2%, which is reasonably good for a spherical case. Although it is obviously desirable to attain the best agreement possible, experience has shown that agreement within 10% is adequate for most analytical purposes. In general, agreement is easier to attain for slab and cylindrical geometries, and for spatially distributed source and response functions. Refinement of the angular quadrature and spatial mesh, especially in the area of the source and response function, usually improves agreement. For example the sample problem gave approximately 25% agreement when calculated with an S_{16} angular quadrature and 155 spatial intervals, before refinement to 2% agreement with S_{40} and 169 spatial intervals.

B. Sample Input

The computer code package for SWANLAKE, (available from the Radiation Shielding Information Center at Oak Ridge as CCC-204), includes a listing of the complete SWANLAKE input and output for the sample problem, along with the input for the forward and adjoint ANISN calculations to produce the angular flux. This section, therefore, contains the first portion of the SWANLAKE output, which is essentially an input listing. Note that this case calculates the $\Phi^*\Phi$ matrix (ITAPE = 1), will print out the cross section set (IPRNT = 1) and P_ℓ predictions (IPLZN = 1), prints the sensitivity matrix in ANISN format (IARNG = 1) and produces both neutron and gamma sensitivity plots (IPLOT = 3) summed over all spatial zones (IPLTZ = 0).

ORNL-DWG 73-3554

```
 44000  WORDS REQUESTED FOR BLANK COMMON
1$ ARRAY      16 ENTRIES READ
2* ARRAY       1 ENTRIES READ
0T
```

ORNL-DWG 73-3526

```
       40  - NUMBER OF ENERGY GROUPS
       43  - CROSS SECTION TABLE LENGTH
      169  - NUMBER OF SPATIAL INTERVALS
       40  - ORDER OF SN
        3  - ORDER OF CROSS SECTION EXPANSION
        4  - NUMBER OF SPATIAL ZONES
        1  - NUMBER OF CROSS SECTION SETS
        1  - 1/2, CALCULATE (PSI*)(PSI)/READ (PSI*)(PSI)
        1  - 1/2, READ CROSS SECTIONS FROM CARDS/TAPE
        3  - 1/2/3, PLANE/CYLINDER/SPHERE GEOMETRY
        1  - 0/1, DO NOT PRINT/PRINT CROSS SECTIONS
        1  - 0/1, DO NCT PRINT/PRINT P(L) SENSITIVITY BY GROUP AND ZONE
        1  - 1/2/3, SENSITIVITY MATRIX PRINTED IN SN/MONTE CARLO/BOTH FORMAT
        3  - 0/1/2/3, SENSITIVITY PLOTS - NO PLOTS/NEUTRON ONLY/GAMMA ONLY/NEUTRON AND GAMMA
        0  - 0/1, DO NOT PLOT/PLOT SENSITIVITY BY ZONE
       22  - LAST NEUTRON GROUP
1.0100E-16 - TOTAL RESPONSE FOR THIS PROBLEM

   4* ARRAY    41 ENTRIES READ

   5* ARRAY    41 ENTRIES READ

   0T
```

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ANGULAR QUADRATURE CONSTANTS

	WEIGHT	COSINE	REFL	DIRECT
1	0.0	-1.00000E 00		41
2	2.26060E-03	-9.98240E-01		41
3	5.24910E-03	-9.90730E-01		40
4	8.21050E-03	-9.77260E-01		39
5	1.11230E-02	-9.57920E-01		38
6	1.39690E-02	-9.32810E-01		37
7	1.67300E-02	-9.02100E-01		36
8	1.93910E-02	-8.65960E-01		35
9	2.19350E-02	-8.24610E-01		34
10	2.43480E-02	-7.78310E-01		33
11	2.66140E-02	-7.27320E-01		32
12	2.87200E-02	-6.71960E-01		31
13	3.06530E-02	-6.12550E-01		30
14	3.24020E-02	-5.49470E-01		29
15	3.39560E-02	-4.83080E-01		28
16	3.53060E-02	-4.13780E-01		27
17	3.64430E-02	-3.41990E-01		26
18	3.73620E-02	-2.68150E-01		25
19	3.80550E-02	-1.92700E-01		24
20	3.85200E-02	-1.16080E-01		23
21	3.87530E-02	-3.87720E-02		22
22	3.87530E-02	3.87720E-02		21
23	3.85200E-02	1.16080E-01		20
24	3.80550E-02	1.92700E-01		19
25	3.73620E-02	2.68150E-01		18
26	3.64430E-02	3.41990E-01		17
27	3.53060E-02	4.13780E-01		16
28	3.39560E-02	4.83080E-01		15
29	3.24020E-02	5.49470E-01		14
30	3.06530E-02	6.12550E-01		13
31	2.87200E-02	6.71960E-01		12
32	2.66140E-02	7.27320E-01		11
33	2.43480E-02	7.78310E-01		10
34	2.19350E-02	8.24610E-01		9
35	1.93910E-02	8.65960E-01		8
36	1.67300E-02	9.02100E-01		7
37	1.39690E-02	9.32810E-01		6
38	1.11230E-02	9.57920E-01		5
39	8.21050E-03	9.77260E-01		4
40	5.24910E-03	9.90730E-01		3
41	2.26060E-03	9.98240E-01		2

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LEGENDRE COEFFICIENTS FOR FLUX EXPANSION

ANG.	P(L) 1	P(L) 2	P(L) 3	P(L) 4
1	1.00000E 00	-1.00000E 00	9.99998E-01	-9.99995E-01
2	1.00000E 00	-9.98240E-01	9.94723E-01	-9.89460E-01
3	1.00000E 00	-9.90730E-01	9.72318E-01	-9.45019E-01
4	1.00000E 00	-9.77260E-01	9.32554E-01	-8.67405E-01
5	1.00000E 00	-9.57920E-01	8.76414E-01	-7.60610E-01
6	1.00000E 00	-9.32810E-01	8.05201E-01	-6.29957E-01
7	1.00000E 00	-9.02100E-01	7.20675E-01	-4.82134E-01
8	1.00000E 00	-8.65960E-01	6.24829E-01	-3.24488E-01
9	1.00000E 00	-8.24610E-01	5.19972E-01	-1.64883E-01
10	1.00000E 00	-7.78310E-01	4.08649E-01	-1.12189E-02
11	1.00000E 00	-7.27320E-01	2.93491E-01	1.29110E-01
12	1.00000E 00	-6.71960E-01	1.77295E-01	2.49415E-01
13	1.00000E 00	-6.12550E-01	6.28262E-02	3.44226E-01
14	1.00000E 00	-5.49470E-01	-4.71242E-02	4.09469E-01
15	1.00000E 00	-4.83080E-01	-1.49951E-01	4.42784E-01
16	1.00000E 00	-4.13780E-01	-2.43179E-01	4.43558E-01
17	1.00000E 00	-3.41990E-01	-3.24564E-01	4.12989E-01
18	1.00000E 00	-2.68150E-01	-3.92143E-01	3.54022E-01
19	1.00000E 00	-1.92700E-01	-4.44300E-01	2.71161E-01
20	1.00000E 00	-1.16080E-01	-4.79788E-01	1.70210E-01
21	1.00000E 00	-3.87720E-02	-4.97745E-01	5.80122E-02
22	1.00000E 00	3.87720E-02	-4.97745E-01	-5.80122E-02
23	1.00000E 00	1.16080E-01	-4.79788E-01	-1.70210E-01
24	1.00000E 00	1.92700E-01	-4.44300E-01	-2.71161E-01
25	1.00000E 00	2.68150E-01	-3.92143E-01	-3.54022E-01
26	1.00000E 00	3.41990E-01	-3.24564E-01	-4.12989E-01
27	1.00000E 00	4.13780E-01	-2.43179E-01	-4.43558E-01
28	1.00000E 00	4.83080E-01	-1.49951E-01	-4.42784E-01
29	1.00000E 00	5.49470E-01	-4.71242E-02	-4.09469E-01
30	1.00000E 00	6.12550E-01	6.28262E-02	-3.44226E-01
31	1.00000E 00	6.71960E-01	1.77295E-01	-2.49415E-01
32	1.00000E 00	7.27320E-01	2.93491E-01	-1.29110E-01
33	1.00000E 00	7.78310E-01	4.08649E-01	1.12189E-02
34	1.00000E 00	8.24610E-01	5.19972E-01	1.64883E-01
35	1.00000E 00	8.65960E-01	6.24829E-01	3.24488E-01
36	1.00000E 00	9.02100E-01	7.20675E-01	4.82134E-01
37	1.00000E 00	9.32810E-01	8.05201E-01	6.29957E-01
38	1.00000E 00	9.57920E-01	8.76414E-01	7.60610E-01
39	1.00000E 00	9.77260E-01	9.32554E-01	8.67405E-01
40	1.00000E 00	9.90730E-01	9.72318E-01	9.45019E-01
41	1.00000E 00	9.98240E-01	9.94723E-01	9.89460E-01

```
 6* ARRAY    170 ENTRIES READ

 7$ ARRAY      5 ENTRIES READ

 0T

   NUMBER OF INTERVALS IN THE LARGEST ZONE IS    126

   42112 WORDS OF BLANK COMMON REQUIRED FOR (PSI*)(PSI) CALCULATION
```

ORNL-DWG 73-3529

DISTANCES FOR INTERVAL BOUNDARIES

INT.	DIST 1
1	0.0
2	2.50000E 01
3	5.00000E 01
4	7.50000E 01
5	1.00000E 02
6	1.02500E 02
7	1.05000E 02
8	1.07500E 02
9	1.10000E 02
10	1.20000E 02
11	1.30000E 02
12	1.40000E 02
13	1.70000E 02
14	2.00000E 02
15	2.40000E 02
16	2.80000E 02
17	3.40000E 02
18	4.00000E 02
19	4.83000E 02
20	5.66000E 02
21	6.83000E 02
22	8.00000E 02
23	9.65000E 02
24	1.13000E 03
25	1.36500E 03
26	1.60000E 03
27	1.93000E 03
28	2.26000E 03
29	2.73000E 03
30	3.20000E 03
31	3.86250E 03
32	4.52500E 03
33	5.46250E 03
34	6.40000E 03
35	7.72500E 03
36	9.05000E 03
37	1.10000E 04
38	1.30000E 04
39	1.50000E 04
40	1.70000E 04
41	1.90000E 04
42	2.10000E 04
43	2.30000E 04
44	2.50000E 04
45	2.70000E 04
46	2.90000E 04
47	3.10000E 04
48	3.30000E 04
49	3.50000E 04
50	3.70000E 04
51	3.90000E 04
52	4.10000E 04
53	4.30000E 04
54	4.50000E 04
55	4.70000E 04
56	4.90000E 04
57	5.10000E 04
58	5.30000E 04
59	5.50000E 04
60	5.70000E 04

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61	5.90000E 04
62	6.10000E 04
63	6.30000E 04
64	6.50000E 04
65	6.70000E 04
66	6.90000E 04
67	7.10000E 04
68	7.30000E 04
69	7.50000E 04
70	7.70000E 04
71	7.90000E 04
72	8.10000E 04
73	8.30000E 04
74	8.50000E 04
75	8.70000E 04
76	8.90000E 04
77	9.10000E 04
78	9.30000E 04
79	9.50000E 04
80	9.70000E 04
81	9.90000E 04
82	1.01000E 05
83	1.03000E 05
84	1.05000E 05
85	1.07000E 05
86	1.09000E 05
87	1.11000E 05
88	1.13000E 05
89	1.15000E 05
90	1.17000E 05
91	1.19000E 05
92	1.21000E 05
93	1.23000E 05
94	1.25000E 05
95	1.27000E 05
96	1.29000E 05
97	1.31000E 05
98	1.33000E 05
99	1.35000E 05
100	1.37000E 05
101	1.39000E 05
102	1.41000E 05
103	1.43000E 05
104	1.45000E 05
105	1.47000E 05
106	1.49000E 05
107	1.51000E 05
108	1.53000E 05
109	1.55000E 05
110	1.57000E 05
111	1.59000E 05
112	1.61000E 05
113	1.63000E 05
114	1.65000E 05
115	1.67000E 05
116	1.69000E 05
117	1.71000E 05
118	1.73000E 05
119	1.75000E 05
120	1.77000E 05
121	1.79000E 05
122	1.81000E 05
123	1.83000E 05
124	1.85000E 05
125	1.87000E 05
126	1.89000E 05

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127	1.91000E 05
128	1.93000E 05
129	1.95000E 05
130	1.97000E 05
131	1.99000E 05
132	2.01000E 05
133	2.03500E 05
134	2.06000E 05
135	2.08500E 05
136	2.11000E 05
137	2.13500E 05
138	2.16000E 05
139	2.18500E 05
140	2.21000E 05
141	2.23500E 05
142	2.26000E 05
143	2.28500E 05
144	2.31000E 05
145	2.33500E 05
146	2.36000E 05
147	2.38500E 05
148	2.41000E 05
149	2.43500E 05
150	2.46000E 05
151	2.48500E 05
152	2.51000E 05
153	2.53500E 05
154	2.56000E 05
155	2.58500E 05
156	2.61000E 05
157	2.63500E 05
158	2.66000E 05
159	2.68500E 05
160	2.71000E 05
161	2.73500E 05
162	2.76000E 05
163	2.78500E 05
164	2.81000E 05
165	2.83500E 05
166	2.86000E 05
167	2.88500E 05
168	2.91000E 05
169	2.93500E 05
170	2.96000E 05

ORNL-DWG 73-3532

```
 INTERVAL BOUNDARIES FOR ZONE BOUNDARIES
ZONE   INTERVAL
  1        1
  2        5
  3      131
  4      132
  5      170

        16956 WORDS OF BLANK COMMON REQUIRED FOR FULL EXPANSION SENSITIVITY CALCULATION

     8* ARRAY      23 ENTRIES READ

     9* ARRAY      19 ENTRIES READ

     OT
```

C. Sample Output

This section contains the remainder of the SWANLAKE output for the sample problem, which primarily consists of the calculated sensitivities. An outline of the output is presented first, along with a brief discussion of its significance.

1. The title for the calculation is printed out first, followed by the cross section set to be analyzed.
2. Number density and predictions of P_ℓ effects are given by zone, followed by P_ℓ predictions for the entire calculation as a function of group. Note that for this problem high energy groups for both neutrons and gammas generally require higher P_ℓ expansions than lower energy groups.
3. Sensitivities for each position in the cross section matrix are given first as a function of P_ℓ, then as the sum of all expansion terms. The information contained here is useful in determining the importance of specific individual cross sections. The sign of the sensitivity indicates the effect of increasing the cross section under investigation. A cross section increase which increases the calculated dose has a positive sensitivity, one which decreases the calculated dose has a negative sensitivity. In general, sensitivities for cross sections in a given energy group I are highest for the total (pos. 3, grp. I), within group (pos. 4, grp. I), and first downscatter (pos. 5, grp. I+1). For this problem, a strong sensitivity to higher energy neutron cross sections is evident. However, it should be noted that the

sensitivity of a given cross section will show a marked dependence on both the input source spectrum and the response function. For example, if the problem to be analyzed considered a fission source and a damage-type response function weighted toward lower energies, the lower energy cross sections would be more important (have a higher sensitivity) than in the current case.

4. Problem sensitivity by group and zone is given next, with sum over all zones given as zone 5. The problem sensitivity to a specific energy group in a given cross section set is determined by summing the sensitivities to the total and within group cross sections for that group plus the sensitivities to all downscatter cross sections from that group.

5. Problem sensitivity by particle type and zone is then presented as sensitivity to neutron cross sections (sum over neutron energy group), sensitivity to gamma cross sections, and sensitivity to (neutron + gamma) cross sections. The sum over all zones appears as zone 5.

6. The concluding output consists of the energy group bounds in MeV for the neutron and gamma groups, and sensitivity per unit lethargy by group and zone.

7. The sensitivity profiles (plots of sensitivity per unit lethargy vs energy) for neutron cross sections and for gamma cross sections are included in the exact form produced by the INTRIGUE-2L plot package included with SWANLAKE. These profiles present the sensitivity information in a compact form which is very convenient for analysis.

SENSITIVITY OF TOTAL DOSE TO .N' AIR X-SEC

10$ ARRAY 1 ENTRIES READ

OT

11* ARRAY 6880 ENTRIES READ

OT

12* ARRAY 4 ENTRIES READ

OT

ORNL-DWG 73-3534

PI 0) CROSS SECTIONS FOR SET 1

POS.	GRP. 1	GRP. 2	GRP. 3	GRP. 4	GRP. 5	GRP. 6	GRP. 7	GRP. 8
1	1.15280E-05	1.02370E-05	7.16040E-06	7.54130E-06	7.46030E-06	1.34570E-05	1.32760E-05	7.34560E-06
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	7.31010E-05	6.69520E-05	5.85680E-05	6.03470E-05	6.35880E-05	7.18280E-05	8.75650E-05	6.35550E-05
4	3.20370E-05	2.89050E-05	2.49830E-05	2.67090E-05	3.07430E-05	3.13240E-05	4.27440E-05	2.03770E-05
5	0.0	1.15210E-05	1.24480E-05	1.66130E-05	1.83470E-05	2.03930E-05	2.61310E-05	2.75260E-05
6	0.0	0.0	1.02770E-06	1.47830E-06	4.31800E-07	3.59720E-07	2.41100E-06	0.0
7	0.0	0.0	0.0	2.31190E-06	1.65680E-06	6.82200E-07	7.32290E-07	1.45940E-07
8	0.0	0.0	0.0	0.0	3.43760E-06	2.17740E-06	1.66840E-06	9.19480E-07
9	0.0	0.0	0.0	0.0	0.0	1.87940E-06	2.88280E-06	2.03160E-06
10	0.0	0.0	0.0	0.0	0.0	0.0	2.36280E-06	1.07680E-06
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.55010E-06
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13 THRU 43 SAME AS ABOVE								

POS.	GRP. 9	GRP. 10	GRP. 11	GRP. 12	GRP. 13	GRP. 14	GRP. 15	GRP. 16
1	3.54420E-06	3.45600E-06	2.79600E-06	1.42530E-06	2.58530E-07	8.97529E-08	3.02170E-07	7.25800E-07
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	5.68670E-05	7.36200E-05	1.01490E-04	1.03140E-04	1.64630E-04	2.69930E-04	3.51920E-04	3.82680E-04
4	6.68320E-06	3.40890E-05	7.44100E-05	8.32210E-05	1.50350E-04	2.59320E-04	3.24420E-04	3.57620E-04
5	8.54650E-06	4.40510E-05	3.60750E-05	2.42830E-05	1.84970E-05	1.40200E-05	1.05240E-05	2.71950E-05
6	3.10380E-06	2.72670E-05	2.58830E-06	0.0	0.0	0.0	0.0	0.0
7	0.0	8.10930E-07	0.0	0.0	0.0	0.0	0.0	0.0
8	3.08890E-08	1.11980E-07	3.44380E-08	0.0	0.0	0.0	0.0	0.0
9	2.61390E-07	5.70560E-08	1.26400E-07	5.86090E-08	1.53350E-08	0.0	0.0	0.0
10	4.26700E-07	1.79280E-06	1.14640E-06	1.29080E-07	8.44179E-09	2.48170E-09	0.0	0.0
11	3.07080E-07	1.71020E-06	1.61360E-06	9.52130E-07	5.20320E-07	0.0	6.38450E-11	0.0
12	3.01430E-07	1.44090E-06	1.41130E-06	1.41140E-05	2.02240E-07	2.83860E-08	0.0	1.10950E-11
13	0.0	1.23500E-06	2.01200E-06	7.35530E-07	5.84620E-07	4.50120E-08	1.60600E-10	0.0
14	0.0	0.0	1.52360E-06	1.17010E-06	6.21430E-07	5.35860E-08	8.61990E-10	2.40200E-11
15	0.0	0.0	0.0	1.19550E-06	7.50900E-07	2.02450E-07	1.40170E-09	1.41420E-10
16	0.0	0.0	0.0	0.0	1.10420E-06	3.04630E-07	1.62150E-08	2.29990E-10
17	0.0	0.0	0.0	0.0	0.0	2.55480E-07	9.15200E-08	2.80250E-09
18	0.0	0.0	0.0	0.0	0.0	0.0	4.40950E-09	1.58520E-08
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.55100E-10
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 THRU 43 SAME AS ABOVE								

POS.	GRP. 17	GRP. 18	GRP. 19	GRP. 20	GRP. 21	GRP. 22	GRP. 23	GRP. 24
1	1.52010E-06	2.65230E-06	4.66610E-06	8.13770E-06	1.33660E-05	6.15020E-05	1.51940E-04	1.27770E-04
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	3.99000E-04	4.02510E-04	4.05820E-04	4.09500E-04	4.14870E-04	4.62980E-04	2.34430E-05	2.55360E-05
4	3.54940E-04	3.46590E-04	3.59600E-04	3.50080E-04	3.52160E-04	4.01490E-04	9.86051E-07	1.14270E-06
5	2.93330E-05	4.25410E-05	5.32680E-05	4.15680E-05	5.12990E-05	4.93380E-05	2.13050E-07	1.61790E-06
6	0.0	0.0	0.0	0.0	0.0	0.0	9.98259E-08	2.20650E-07
7	0.0	0.0	0.0	0.0	0.0	0.0	6.05439E-08	5.06800E-08
8	0.0	0.0	0.0	0.0	0.0	0.0	3.39210E-08	3.07360E-08
9	0.0	0.0	0.0	0.0	0.0	0.0	1.96690E-08	1.72200E-08
10	0.0	0.0	0.0	0.0	0.0	0.0	1.10260E-08	9.98330E-09
11	0.0	0.0	0.0	0.0	0.0	0.0	4.99730E-09	5.59350E-09
12	0.0	0.0	0.0	0.0	0.0	0.0	2.11640E-09	2.52700E-09
13	1.66490E-12	0.0	0.0	0.0	0.0	0.0	6.42740E-10	1.05040E-09
14	0.0	4.22600E-13	0.0	0.0	0.0	0.0	7.60500E-10	1.98960E-10
15	3.50520E-12	0.0	1.75480E-13	0.0	0.0	0.0	9.74840E-10	2.41930E-11
16	1.72020E-11	7.39320E-13	0.0	4.45430E-14	0.0	0.0	1.27790E-09	0.0
17	2.87170E-11	3.37740E-12	0.0	0.0	5.73380E-15	0.0	9.89390E-10	0.0
18	4.15570E-10	2.53870E-12	0.0	0.0	0.0	0.0	7.65770E-10	0.0
19	2.37020E-09	1.02100E-10	1.05420E-12	0.0	0.0	0.0	5.14720E-10	0.0
20	8.42550E-11	5.89680E-10	4.24180E-11	2.67580E-13	0.0	0.0	4.38650E-10	0.0
21	0.0	0.0	2.36700E-10	0.0	3.44450E-14	0.0	5.34170E-11	0.0
22	0.0	0.0	0.0	6.00820E-11	0.0	0.0	0.0	0.0

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23	0.0	0.0	0.0	0.0	1.84490E-11	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	9.44880E-10	2.61880E-07
25	0.0	0.0	0.0	0.0	0.0	0.0	7.25900E-08	1.47430E-06
26	0.0	0.0	0.0	0.0	0.0	0.0	2.69820E-07	3.09750E-06
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.55900E-06
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 THRU	43 SAME AS ABOVE							

POS.	GRP. 25	GRP. 26	GRP. 27	GRP. 28	GRP. 29	GRP. 30	GRP. 31	GRP. 32
1	1.07950E-04	9.09010E-05	7.65090E-05	6.50690E-05	5.67430E-05	4.91550E-05	4.24670E-05	3.50990E-05
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.84840E-05	3.21410E-05	3.66540E-05	4.16240E-05	4.63080E-05	5.17850E-05	5.76290E-05	6.55800E-05
4	1.79140E-06	1.96410E-06	3.18910E-06	2.64630E-06	3.89650E-06	4.03630E-06	5.78040E-06	9.25770E-06
5	2.48900E-06	2.64600E-06	4.27950E-06	3.52970E-06	5.58540E-06	5.64800E-06	8.16410E-06	1.20390E-05
6	1.71410E-06	1.76190E-06	2.81220E-06	2.24640E-06	3.63190E-06	3.85070E-06	5.50800E-06	8.13980E-06
7	2.21990E-06	1.27210E-06	1.97750E-06	1.55830E-06	2.43420E-06	2.63350E-06	3.93400E-06	5.83770E-06
8	5.09880E-07	3.67760E-07	1.48650E-06	1.14370E-06	1.75630E-06	1.85090E-06	2.81790E-06	4.40280E-06
9	3.09220E-07	8.44659E-08	6.24050E-07	8.85060E-07	1.32650E-06	1.38020E-06	2.06010E-06	3.31060E-06
10	1.73240E-07	5.12260E-08	1.43340E-07	1.76080E-07	1.04530E-06	1.06610E-06	1.57560E-06	2.51270E-06
11	1.00440E-07	2.87000E-08	8.69319E-08	4.04430E-08	2.22880E-09	8.51580E-07	1.23680E-06	1.96480E-06
12	5.62750E-08	1.66390E-08	4.87020E-08	2.45270E-08	5.11930E-10	7.68890E-07	9.97330E-07	1.56330E-06
13	2.54230E-08	9.32270E-09	2.82350E-08	1.37410E-08	3.10460E-10	1.76610E-07	0.0	1.27000E-06
14	1.05680E-08	4.21180E-09	1.58200E-08	7.96660E-09	1.73940E-10	1.07110E-07	0.0	4.45760E-09
15	2.00160E-09	1.75070E-09	7.14730E-09	4.46350E-09	1.00840E-10	6.00090E-08	0.0	1.02380E-09
16	2.43390E-10	3.31600E-10	2.97090E-09	2.01650E-09	5.65020E-11	3.47900E-08	0.0	6.70940E-10
17	0.0	4.03220E-11	5.62720E-10	8.38210E-10	2.55260E-11	1.94930E-08	0.0	3.47870E-10
18	0.0	0.0	6.84250E-11	1.58760E-10	1.06100E-11	8.80640E-09	0.0	2.01680E-10
19	0.0	0.0	0.0	1.93050E-11	2.00970E-12	3.66060E-09	0.0	1.13000E-10
20	0.0	0.0	0.0	0.0	2.44370E-13	6.93340E-10	0.0	5.10500E-11
21	0.0	0.0	0.0	0.0	0.0	8.43080E-11	0.0	2.12200E-11
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.01940E-12
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.88740E-13
24	2.58310E-07	1.33270E-11	0.0	0.0	1.17830E-11	0.0	0.0	0.0
25	3.35490E-06	3.72770E-07	2.40050E-08	0.0	2.26370E-08	0.0	0.0	0.0
26	4.94090E-06	1.79830E-06	9.47319E-08	0.0	1.75590E-07	0.0	0.0	0.0
27	4.33570E-06	1.60970E-06	6.91680E-07	8.09189E-08	1.81310E-06	0.0	0.0	0.0
28	3.98230E-06	2.34860E-06	1.92330E-06	5.85800E-07	3.83950E-06	0.0	0.0	0.0
29	0.0	2.54370E-06	3.19910E-06	6.31420E-07	5.39380E-06	0.0	6.07710E-07	0.0
30	0.0	0.0	3.16590E-06	6.97050E-07	3.95890E-06	0.0	1.80660E-06	0.0
31	0.0	0.0	0.0	6.39950E-07	3.83440E-06	2.20460E-09	2.84360E-06	1.57120E-09
32	0.0	0.0	0.0	0.0	2.73540E-06	4.49150E-08	1.63510E-06	3.09940E-08
33	0.0	0.0	0.0	0.0	0.0	3.87270E-08	1.54610E-06	1.41300E-07
34	0.0	0.0	0.0	0.0	0.0	0.0	8.96840E-07	2.61170E-07
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.34130E-07
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37 THRU	43 SAME AS ABOVE							

POS.	GRP. 33	GRP. 34	GRP. 35	GRP. 36	GRP. 37	GRP. 38	GRP. 39	GRP. 40
1	2.84210E-05	2.27540E-05	1.64800E-05	1.13640E-05	7.75790E-06	4.15390E-06	1.96120E-06	7.50550E-06
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	7.43950E-05	8.36720E-05	9.70070E-05	1.11730E-04	1.26550E-04	1.49730E-04	1.82750E-04	6.49440E-04
4	9.50930E-06	1.51320E-05	2.74680E-05	2.84310E-05	4.92950E-05	1.12510E-04	1.56050E-04	1.98700E-04
5	1.18120E-05	1.89820E-05	2.93060E-05	2.68540E-05	4.89460E-05	7.71130E-05	3.64470E-05	1.94630E-05
6	7.20970E-06	1.14020E-05	1.78830E-05	1.41260E-05	2.78400E-05	3.43040E-05	0.0	0.0
7	5.22140E-06	7.56060E-06	1.25230E-05	1.05940E-05	2.07180E-05	1.48270E-05	0.0	0.0
8	3.97430E-06	5.91890E-06	9.65720E-06	8.42590E-06	1.69250E-05	4.38290E-06	0.0	0.0
9	3.14060E-06	4.72770E-06	8.37980E-06	6.82040E-06	1.21580E-05	4.95640E-07	0.0	0.0
10	2.45090E-06	3.86240E-06	7.66960E-06	5.74740E-06	8.54970E-06	0.0	0.0	0.0
11	1.90910E-06	3.08600E-06	7.41920E-06	4.81490E-06	6.46540E-06	0.0	0.0	0.0
12	1.51410E-06	2.43960E-06	7.58080E-06	4.02880E-06	4.90430E-06	0.0	0.0	0.0
13	1.21430E-06	1.94860E-06	8.22830E-06	3.24980E-06	3.75550E-06	0.0	0.0	0.0
14	9.90630E-07	1.56820E-06	9.19700E-06	2.56930E-06	2.77150E-06	0.0	0.0	0.0
15	2.22880E-09	1.28110E-06	1.03030E-05	2.04210E-06	2.01690E-06	0.0	0.0	0.0
16	5.11930E-10	0.0	1.18290E-05	1.63330E-06	1.50210E-06	0.0	0.0	0.0
17	3.10460E-10	0.0	6.68640E-09	1.32650E-06	1.13980E-06	0.0	0.0	0.0
18	1.73940E-10	0.0	1.53580E-09	0.0	8.89500E-07	0.0	0.0	0.0

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19	1.00840E-10	0.0	9.31390E-10	0.0	0.0	0.0	0.0	0.0
20	5.65020E-11	0.0	5.21830E-10	0.0	0.0	0.0	0.0	0.0
21	2.55260E-11	0.0	3.02520E-10	0.0	0.0	0.0	0.0	^.0
22	1.06100E-11	0.0	1.69500E-10	0.0	0.0	0.0	0.0	0.0
23	2.00970E-12	0.0	7.65770E-11	0.0	0.0	0.0	0.0	0.0
24	2.44370E-13	0.0	3.18310E-11	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	6.02910E-12	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	7.33130E-13	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	THRU	32 SAME AS ABOVE						
33	0.0	6.71430E-09	0.0	0.0	0.0	0.0	0.0	n.0
34	0.0	6.40170E-07	0.0	0.0	0.0	0.0	0.0	0.0
35	0.0	8.60750E-07	5.03120E-07	0.0	0.0	0.0	0.0	0.0
36	0.0	8.90790E-07	6.68530E-07	0.0	0.0	0.0	0.0	0.0
37	0.0	8.60930E-07	6.73190E-07	0.0	0.0	0.0	0.0	0.0
38	0.0	0.0	4.70240E-07	0.0	0.0	4.56240E-09	0.0	C.0
39	0.0	0.0	0.0	0.0	0.0	6.52689E-08	0.0	0.0
40	0.0	0.0	0.0	0.0	0.0	2.42770E-07	0.0	0.0
41	0.0	0.0	0.0	0.0	0.0	2.68370E-07	^.0	0.0
42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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P(1) CROSS SECTIONS FOR SET 1

POS.	GRP. 1	GRP. 2	GRP. 3	GRP. 4	GRP. 5	GRP. 6	GRP. 7	GRP. 8
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	8.00560E-05	6.76410E-05	5.58360E-05	5.35860E-05	6.32100E-05	7.14050E-05	6.64370E-05	3.86280E-05
5	0.0	2.86220E-06	-3.96790E-06	-1.08040E-05	-1.12030E-05	-1.95980E-05	-2.34120E-05	-3.18400E-05
6	0.0	0.0	-1.52340E-06	-2.29330E-06	-4.44150E-07	-3.93530E-07	-5.79570E-06	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	THRU 43 SAME AS ABOVE							

POS.	GRP. 9	GRP. 10	GRP. 11	GRP. 12	GRP. 13	GRP. 14	GRP. 15	GRP. 16
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	1.79580E-05	5.26190E-05	6.73140E-05	4.16410E-05	4.04200E-05	4.64920E-05	7.44500E-05	8.07850E-05
5	3.93700E-06	-4.03410E-06	-2.89810E-05	-1.88960E-05	-1.26950E-05	-1.28350E-05	-9.47440E-06	-2.45070E-05
6	-7.34100E-06	-3.99940E-05	-7.11260E-06	0.0	0.0	0.0	0.0	0.0
7	0.0	-2.21520E-06	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	THRU 43 SAME AS ABOVE							

POS.	GRP. 17	GRP. 18	GRP. 19	GRP. 20	GRP. 21	GRP. 22	GRP. 23	GRP. 24
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	9.49960E-05	1.05030E-04	9.46760E-05	1.03520E-04	1.01740E-04	0.0	2.94600E-06	3.41190E-06
5	-2.64330E-05	-3.84040E-05	-4.80990E-05	-3.75560E-05	-4.63710E-05	-4.46450E-05	0.0	4.78910E-06
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	THRU 43 SAME AS ABOVE							

POS.	GRP. 25	GRP. 26	GRP. 27	GRP. 28	GRP. 29	GRP. 30	GRP. 31	GRP. 32
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	5.33370E-06	5.84390E-06	9.43820E-06	7.85220E-06	1.14990E-05	1.19060E-05	1.69200E-05	2.66730E-05
5	7.33060E-06	7.74940E-06	1.24250E-05	1.01930E-05	1.60750E-05	1.60970E-05	2.29910E-05	3.26850E-05
6	4.97730E-06	5.05810E-06	7.95440E-06	6.25600E-06	1.00290E-05	1.04790E-05	1.46470E-05	2.05030E-05
7	0.0	3.59910E-06	5.47900E-06	4.22380E-06	6.47160E-06	6.85900E-06	9.95450E-06	1.37800E-05
8	0.0	0.0	4.05630E-06	3.03450E-06	4.53850E-06	4.63140E-06	6.79980E-06	9.82410E-06
9	0.0	0.0	0.0	2.31140E-06	3.35170E-06	3.35100E-06	4.76110E-06	6.99420E-06
10	0.0	0.0	0.0	0.0	2.59780E-06	2.52750E-06	3.52390E-06	5.05370E-06
11	0.0	0.0	0.0	0.0	0.0	1.98370E-06	2.69570E-06	3.80510E-06
12	0.0	0.0	0.0	0.0	0.0	0.0	2.13250E-06	2.93840E-06
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.33460E-06
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	THRU 43 SAME AS ABOVE							

POS.	GRP. 33	GRP. 34	GRP. 35	GRP. 36	GRP. 37	GRP. 38	GRP. 39	GRP. 40
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	2.73790E-05	4.24190E-05	7.21060E-05	7.44760E-05	1.12950E-04	1.09660E-04	7.13320E-05	2.49990E-05
5	3.11340E-05	4.79810E-05	6.30290E-05	4.88950E-05	6.48210E-05	-3.30870E-05	-4.08670E-05	-2.23020E-05
6	1.67700E-05	2.43490E-05	2.87840E-0[illegible]	1.13240E-05	-4.22180E-06	-5.58640E-05	0.0	0.0
7	1.11250E-05	1.39760E-05	1.50750E-05	2.94500E-06	-2.36930E-05	-3.30930E-05	0.0	0.0
8	7.84220E-06	9.63880E-06	8.43840E-06	-9.57140E-07	-2.76620E-05	-2.18090E-05	0.0	0.0
9	5.79470E-06	6.95030E-06	5.40820E-06	-2.83130E-06	-2.26360E-05	-1.44590E-06	0.0	0.0
10	4.23450E-06	5.18270E-06	3.46400E-06	-3.48410E-06	-1.72100E-05	0.0	0.0	0.0
11	3.10520E-06	3.77800E-06	[illegible].20350E[illegible]	-3.66500E-06	-1.36410E-05	0.0	0.0	0.0
12	2.35040E-06	2.74010E-06	1.27040E[illegible]	-3.57210E-06	-1.07350E-05	0.0	0.0	0.0
13	1.81610E-06	2.04420E-06	6.60[illegible]	-3.25700E-06	-8.46370E-06	0.0	0.0	0.0
14	1.44060E-06	1.55620E-06	3.23510E-07	-2.83030E-06	-6.41100E-06	0.0	0.0	0.0
15	0.0	1.21850E-06	1.34120E-07	-2.39850E-06	-4.77060E-06	0.0	0.0	0.0
16	0.0	0.0	3.47270E-08	-2.00980E-06	-3.60980E-06	0.0	0.0	0.0
17	0.0	0.0	0.0	-1.66620E-06	-2.77280E-06	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	-2.18280E-06	0.0	0.0	0.0

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19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	THRU 43 SAME AS ABOVE							

P(2) CROSS SECTIONS FOR SET 1

POS.	GRP. 1	GRP. 2	GRP. 3	GRP. 4	GRP. 5	GRP. 6	GRP. 7	GRP. 8
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	9.99540E-05	7.81290E-05	6.09030E-05	5.51850E-05	6.35480E-05	7.36640E-05	6.16230E-05	2.69080E-05
5	0.0	-6.91090E-06	-7.71100E-06	-5.25420E-06	-2.30120E-06	2.97920E-06	9.93870E-06	1.14990E-05
6	0.0	0.0	1.64660E-06	2.60620E-06	6.33250E-07	5.15210E-07	6.46990E-06	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	THRU 43 SAME AS ABOVE							

POS.	GRP. 9	GRP. 10	GRP. 11	GRP. 12	GRP. 13	GRP. 14	GRP. 15	GRP. 16
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	2.38100E-05	2.51260E-05	4.29430E-05	2.49520E-05	1.58010E-05	2.27130E-06	4.40080E-06	4.76570E-06
5	-5.83940E-06	-1.44890E-05	1.55420E-06	7.13290E-06	-3.42690E-06	-1.13030E-06	-1.01080E-06	-2.59340E-06
6	7.15650E-06	1.10030E-05	9.88390E-06	0.0	0.0	0.0	0.0	0.0
7	0.0	3.03950E-06	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	THRU 43 SAME AS ABOVE							

POS.	GRP. 17	GRP. 18	GRP. 19	GRP. 20	GRP. 21	GRP. 22	GRP. 23	GRP. 24
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	6.04890E-06	7.05160E-06	5.92680E-06	6.77720E-06	6.52190E-06	0.0	4.86980E-06	5.63270E-06
5	-2.79570E-06	-3.99720E-06	-4.98800E-06	-3.85500E-06	-4.70540E-06	-4.43870E-06	0.0	7.76870E-06
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	THRU 43 SAME AS ABOVE							

POS.	GRP. 25	GRP. 26	GRP. 27	GRP. 28	GRP. 29	GRP. 30	GRP. 31	GRP. 32
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	8.75600E-06	9.58100E-06	1.53070E-05	1.28000E-05	1.85410E-05	1.91780E-05	2.68360E-05	4.09570E-05
5	1.17710E-05	1.23010E-05	1.93700E-05	1.57120E-05	2.46020E-05	2.41270E-05	3.35870E-05	4.40170E-05
6	7.75810E-06	7.69730E-06	1.17230E-05	8.90550E-06	1.40090E-05	1.41450E-05	1.87160E-05	2.27790E-05
7	0.0	5.30600E-06	7.70880E-06	5.64610E-06	8.25730E-06	8.31040E-06	1.11720E-05	1.25920E-05
8	0.0	0.0	5.51000E-06	3.85060E-06	5.38580E-06	5.03420E-06	6.64270E-06	7.39760E-06
9	0.0	0.0	0.0	2.81870E-06	3.74360E-06	3.33250E-06	4.02720E-06	4.08130E-06
10	0.0	0.0	0.0	0.0	2.76870E-06	2.33040E-06	2.63570E-06	2.21460E-06
11	0.0	0.0	0.0	0.0	0.0	1.72340E-06	1.80900E-06	1.24980E-06
12	0.0	0.0	0.0	0.0	0.0	0.0	1.31010E-06	7.10310E-07
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.14020E-07
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	THRU 43 SAME AS ABOVE							

POS.	GRP. 33	GRP. 34	GRP. 35	GRP. 36	GRP. 37	GRP. 38	GRP. 39	GRP. 40
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	4.19800E-05	6.15340E-05	9.09510E-05	9.34690E-05	1.05320E-04	7.20020E-05	8.45180E-05	1.00720E-04
5	3.90950E-05	5.43340E-05	4.38270E-05	1.33340E-05	-2.19900E-05	-2.12200E-05	1.54760E-05	8.73930E-06
6	1.45790E-05	1.52710E-05	-3.88640E-06	-2.57100E-05	-5.22910E-05	1.06000E-05	0.0	0.0
7	6.76300E-06	2.34300E-06	-1.46130E-05	-2.44820E-05	-1.90570E-05	2.75220E-05	0.0	0.0
8	3.00690E-06	-1.53990E-06	-1.63320E-05	-1.99290E-05	3.08700E-06	1.57110E-05	0.0	0.0
9	1.09320E-06	-3.16280E-06	-1.54840E-05	-1.52720E-05	8.97680E-06	2.27760E-06	0.0	0.0
10	-2.86660E-09	-3.74760E-06	-1.39100E-05	-1.19460E-05	9.71490E-06	0.0	0.0	0.0
11	-5.43680E-07	-3.76970E-06	-1.21730E-05	-9.15870E-06	9.17690E-06	0.0	0.0	0.0
12	-7.28610E-07	-3.46440E-06	-1.01510E-05	-6.97320E-06	8.17230E-06	0.0	0.0	0.0
13	-7.59890E-07	-3.02850E-06	-8.21530E-06	-5.03220E-06	7.05720E-06	0.0	0.0	0.0
14	-7.20450E-07	-2.58900E-06	-6.62160E-06	-3.53290E-06	5.77420E-06	0.0	0.0	0.0
15	0.0	-2.20060E-06	-5.34420E-06	-2.52550E-06	4.57390E-06	0.0	0.0	0.0
16	0.0	0.0	-4.36460E-06	-1.83710E-06	3.61520E-06	0.0	0.0	0.0
17	0.0	0.0	0.0	-1.37960E-06	2.86790E-06	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	2.30980E-06	0.0	0.0	0.0

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19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	THRU 43 SAME AS ABOVE							

P(3) CROSS SECTIONS FOR SET 1

POS.	GRP. 1	GRP. 2	GRP. 3	GRP. 4	GRP. 5	GRP. 6	GRP. 7	GRP. 8
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	1.04490E-04	8.17790E-05	6.27370E-05	6.01080E-05	5.75150E-05	5.72120E-05	4.80140E-05	1.45790E-05
5	0.0	1.80130E-06	4.57250E-06	5.62720E-06	1.04480E-05	1.00200E-05	-2.97650E-07	2.20900E-06
6	0.0	0.0	-1.16860E-06	-2.00540E-06	-6.94580E-07	-4.83420E-07	-4.56930E-06	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	THRU 43 SAME AS ABOVE							

POS.	GRP. 9	GRP. 10	GRP. 11	GRP. 12	GRP. 13	GRP. 14	GRP. 15	GRP. 16
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	2.30690E-05	1.32780E-05	1.74710E-05	1.57490E-06	1.92250E-06	-3.41920E-08	1.91330E-08	2.71600E-08
5	-2.70330E-07	-1.43500E-06	-2.33430E-06	-6.54600E-06	-1.75290E-06	-4.02550E-08	-4.77190E-08	-1.13070E-07
6	-3.32760E-06	5.86170E-07	-1.03510E-05	0.0	0.0	0.0	0.0	0.0
7	0.0	-3.11680E-06	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	THRU 43 SAME AS ABOVE							

POS.	GRP. 17	GRP. 18	GRP. 19	GRP. 20	GRP. 21	GRP. 22	GRP. 23	GRP. 24
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	6.26400E-08	1.20810E-07	9.76559E-08	1.97510E-07	1.34600E-07	0.0	6.73390E-06	7.77390E-06
5	-1.26810E-07	-1.65460E-07	-2.24800E-07	-2.02030E-07	-3.01200E-07	-3.64960E-07	0.0	1.04380E-05
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	THRU 43 SAME AS ABOVE							

POS.	GRP. 25	GRP. 26	GRP. 27	GRP. 28	GRP. 29	GRP. 30	GRP. 31	GRP. 32
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	1.19820E-05	1.30840E-05	2.05640E-05	1.73300E-05	2.46880E-05	2.54980E-05	3.48380E-05	5.05470E-05
5	1.55670E-05	1.59740E-05	2.44430E-05	1.94630E-05	3.01230E-05	2.85260E-05	3.79910E-05	4.28000E-05
6	9.78120E-06	9.32310E-06	1.34360E-05	9.56860E-06	1.45310E-05	1.36770E-05	1.60450E-05	1.31040E-05
7	0.0	6.07980E-06	8.09960E-06	5.[illegible]990E-06	7.02860E-06	6.19590E-06	6.57050E-06	1.91300E-06
8	0.0	0.0	5.39250E-06	3.22970E-06	3.77870E-06	2.60900E-06	1.94070E-06	-2.43560E-06
9	0.0	0.0	0.0	2.13290E-06	2.15230E-06	1.09120E-06	-1.37060E-07	-4.35290E-06
10	0.0	0.0	0.0	0.0	1.31780E-06	3.72850E-07	-8.74730E-07	-4.31510E-06
11	0.0	0.0	0.0	0.0	0.0	4.23610E-08	-1.11090E-06	-3.975[illegible]E-06
12	0.0	0.0	0.0	0.0	0.0	0.0	-1.12600E-06	-3.486[illegible]E-06
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-3.003[illegible]E-06
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	THRU 43 SAME AS ABOVE							

POS.	GRP. 33	GRP. 34	GRP. 35	GRP. 36	GRP. 37	GRP. 38	GRP. 39	GRP. 40
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	5.16940E-05	6.93260E-05	8.08730E-05	8.22380E-05	5.31360E-05	3.28750E-05	1.96150E-05	6.57860E-06
5	3.26970E-05	3.50280E-05	-1.12380E-05	-3.97130E-05	-6.94940E-05	-2.19150E-05	-1.00570E-05	-5.59450E-06
6	6.49010E-07	-1.10590E-05	-4.42540E-05	-3.11720E-05	7.98160E-06	2.43670E-05	0.0	0.0
7	-5.89210E-06	-1.77240E-05	-3.43030E-05	-9.33840E-06	3.55300E-05	-6.33400E-06	0.0	0.0
8	-7.43990E-06	-1.64960E-05	-2.29390E-05	3.04360E-06	1.93410E-05	-1.51790E-05	0.0	0.0
9	-7.34720E-06	-1.41060E-05	-1.58260E-05	8.80200E-06	9.85190E-06	-2.92520E-06	0.0	0.0
10	-6.51610E-06	-1.17410E-05	-1.05800E-05	1.04140E-05	4.57590E-06	0.0	0.0	0.0
11	-5.46700E-06	-9.29450E-06	-6.91200E-06	1.04560E-05	1.68500E-06	0.0	0.0	0.0
12	-4.49730E-06	-7.16760E-06	-4.05630E-06	9.72100E-06	-1.30130E-07	0.0	0.0	0.0
13	-3.67970E-06	-5.56060E-06	-2.13650E-06	8.40060E-06	-1.14430E-06	0.0	0.0	0.0
14	-3.03290E-06	-4.35090E-06	-1.05560E-06	6.92210E-06	-1.63980E-06	0.0	0.0	0.0
15	0.0	-3.47010E-06	-4.43250E-07	5.60840E-06	-1.78250E-06	0.0	0.0	0.0
16	0.0	0.0	-1.20260E-07	4.52540E-06	-1.66960E-06	0.0	0.0	0.0
17	0.0	0.0	0.0	3.68580E-06	-1.47910E-06	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	-1.28000E-06	0.0	0.0	0.0

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19   0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
20 THRU   43 SAME AS ABOVE


DENSITY FOR SET  1 IN ZONE  1 IS  1.00000E 00
   P(L) EVALUATION FOR ZONE  1
   PREDICTED PERCENT CHANGES FROM P( 3) CALCULATIONS FOR P( 0)=-5.40282E-05
   PREDICTED PERCENT CHANGES FROM P( 3) CALCULATIONS FOR P( 1)=-8.27761E-08
   PREDICTED PERCENT CHANGES FROM P( 3) CALCULATIONS FOR P( 2)=-2.91003E-09

DENSITY FOR SET  1 IN ZONE  2 IS  1.00000E 00
   P(L) EVALUATION FOR ZONE  2
   PREDICTED PERCENT CHANGES FROM P( 3) CALCULATIONS FOR P( 0)=-9.58830E 01
   PREDICTED PERCENT CHANGES FROM P( 3) CALCULATIONS FOR P( 1)=-6.77304E 00
   PREDICTED PERCENT CHANGES FROM P( 3) CALCULATIONS FOR P( 2)= 1.89243E 00

DENSITY FOR SET  1 IN ZONE  3 IS  1.00000E 00
   P(L) EVALUATION FOR ZONE  3
   PREDICTED PERCENT CHANGES FROM P( 3) CALCULATIONS FOR P( 0)= 1.20889E 00
   PREDICTED PERCENT CHANGES FROM P( 3) CALCULATIONS FOR P( 1)= 1.07521E 00
   PREDICTED PERCENT CHANGES FROM P( 3) CALCULATIONS FOR P( 2)=-9.80530E-02

DENSITY FOR SET  1 IN ZONE  4 IS  1.00000E 00
   P(L) EVALUATION FOR ZONE  4
   PREDICTED PERCENT CHANGES FROM P( 3) CALCULATIONS FOR P( 0)= 6.93141E 00
   PREDICTED PERCENT CHANGES FROM P( 3) CALCULATIONS FOR P( 1)=-1.14674E 00
   PREDICTED PERCENT CHANGES FROM P( 3) CALCULATIONS FOR P( 2)=-1.58658E 00


P(L) EVALUATION OF CROSS SECTION SET  1 FOR SYSTEM
   PREDICTED PERCENT CHANGES FROM P( 3) CALCULATIONS FOR P( 0)=-8.77426E 01
   PREDICTED PERCENT CHANGES FROM P( 3) CALCULATIONS FOR P( 1)=-6.84459E 00
   PREDICTED PERCENT CHANGES FROM P( 3) CALCULATIONS FOR P( 2)= 2.07803E-01
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PREDICTED PERCENT CHANGES FROM P(3) BY GROUP AND NUMBER OF TERMS IN THE LEGENDPE FXPANSION

GRP.	TRMS 1	TRMS 2	TRMS 3
1	-1.38920E 01	-1.48121E 00	-8.09079E-02
2	-9.85576E 00	-9.42529E-01	-4.37536E-02
3	-8.85370E 00	-8.35917E-01	-1.65735E-02
4	-7.25427E 00	-6.66752E-01	-2.0[illegible]590E-02
5	-8.56785E 00	-9.04610E-01	-2.04085E-02
6	-5.19430E 00	-4.88519E-01	-1.14819E-02
7	2.54885E-01	-2.42943E-01	-2.68267E-03
8	-1.26745E 00	-2.22200E-01	-4.00482E-03
9	-6.74787E-01	-7.65537E-02	-1.89382E-03
10	-4.54574E 00	-1.96551E-01	-3.46435E-03
11	-5.98822E 00	-1.91804E-01	-1.56448E-03
12	-4.99929E 00	-1.09992E-01	-1.86590E-04
13	-1.55341E 00	-8.59033E-03	-1.46450E-05
14	-5.60147E-01	-1.17905E-04	1.16415E-07
15	-9.45433E-02	-1.17579E-05	0.0
16	-6.57182E-02	-5.54[illegible]7E-06	0.0
17	-3.21484E-02	-1.72295E-06	2.32831E-08
18	-2.04342E-02	-1.35042E-06	0.0
19	-2.10020E-02	-1.30385E-06	0.0
20	-1.28722E-02	-1.21072E-06	-3.72529E-07
21	-1.02141E-02	-7.68341E-07	0.0
22	0.0	0.0	0.0
23	-7.39499E-01	3.09241E-02	3.58195E-02
24	-1.72560E 00	-1.46725E-02	7.74591E-02
25	-4.82881E 00	-1.69045E-01	1.79614E-01
26	-1.78353E 00	-5.47619E-02	5.99905E-02
27	-1.75248E 00	-8.83777E-02	4.26427E-02
28	-6.95225E-01	-3.22762E-02	1.17301E-02
29	-8.73061E-01	-6.33181E-02	6.15710E-03
30	-5.11620E-01	-3.07382E-02	1.87184E-03
31	-4.69767E-01	-2.51011E-02	2.59094E-04
32	-4.20987E-01	-1.67164E-02	-3.47871E-04
33	-2.23799E-01	-5.90168E-03	-2.08097E-04
34	-2.02457E-01	-3.65318E-03	-5.82077E-05
35	-1.90239E-01	-2.38984E-03	5.51809E-06
36	-4.82387E-02	-4.25125E-04	-2.74973E-05
37	-1.16901E-02	7.24802E-05	-4.61005E-06
38	-4.41716E-02	-4.19794E-05	-3.56231E-06
39	-1.27436E-02	1.31084E-04	-2.09548E-07
40	1.18744E-06	1.23400E-06	0.0

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SENSITIVITY MATRIX FOR CROSS SECTION SET 1 IN SN FORMAT

P(0)

POS.	GRP. 1	GRP. 2	GRP. 3	GRP. 4	GRP. 5	GRP. 6	GRP. 7	GRP. 8
1	-2.09532E-01	-1.80822E-01	-1.42706E-01	-1.45004E-01	-1.59947E-01	-1.76258E-01	-1.54448E-01	-1.21620E-01
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	-1.32867E 00	-1.18261E 00	-1.16924E 00	-1.16035E 00	-1.36331E 00	-9.40793E-01	-1.01870E 00	-1.05227E 00
4	4.09842E-01	3.63144E-01	3.51336E-01	3.78525E-01	4.86699E-01	3.24785E-01	4.49573E-01	2.68078E-01
5	0.0	1.61982E-01	1.79600E-01	1.89061E-01	2.05163E-01	2.42718E-01	2.67133E-01	3.32159E-01
6	0.0	0.0	1.66872E-02	1.68672E-02	3.85486E-03	2.99974E-03	2.84384E-02	0.0
7	0.0	0.0	0.0	2.89512E-02	1.44600E-02	4.50142E-03	6.01004E-03	1.97883E-02
8	0.0	0.0	0.0	0.0	3.19706E-02	1.34968E-02	1.07514E-02	8.67178E-03
9	0.0	0.0	0.0	0.0	0.0	1.18323E-02	1.68367E-02	1.48151E-02
10	0.0	0.0	0.0	0.0	0.0	0.0	1.33998E-02	7.20218E-03
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00064E-02
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13 THRU	43 SAME AS ABOVE							

POS.	GRP. 9	GRP. 10	GRP. 11	GRP. 12	GRP. 13	GRP. 14	GRP. 15	GRP. 16
1	-2.26263E-02	-7.54598E-02	-9.10115E-02	-6.69040E-02	-1.14264E-02	-3.91081E-03	-3.33075E-03	-6.45257E-03
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	-3.63041E-01	-1.60745E 00	-3.30356E 00	-4.84142E 00	-7.27623E 00	-1.17617E 01	-3.87913E 00	-3.40213E 00
4	3.17242E-02	6.11766E-01	2.17434E 00	3.56649E 00	6.45390E 00	1.12001E 01	3.56065E 00	3.12397E 00
5	1.15837E-01	1.61395E-01	4.69751E-01	4.78224E-01	4.01442E-01	3.02498E-01	2.68904E-01	2.51819E-01
6	3.85371E-02	2.82181E-01	6.92455E-03	0.0	0.0	0.0	0.0	0.0
7	0.0	7.64501E-03	0.0	0.0	0.0	0.0	0.0	0.0
8	4.33062E-04	1.05389E-03	2.33425E-04	0.0	0.0	0.0	0.0	0.0
9	2.73980E-03	6.25076E-04	8.87966E-04	2.67930E-04	3.95014E-05	0.0	0.0	0.0
10	3.25490E-03	1.35023E-02	9.30178E-03	6.11097E-04	1.97250E-05	3.27108E-06	0.0	0.0
11	2.09889E-03	9.97763E-03	8.90210E-03	5.32025E-03	1.27525E-03	0.0	4.84043E-08	0.0
12	1.96566E-03	7.13989E-03	5.95776E-03	5.31705E-03	5.88987E-04	3.53741E-05	0.0	6.94354E-09
13	0.0	5.47854E-03	6.78978E-03	2.10032E-03	1.13640E-03	6.64901E-05	1.12634E-07	0.0
14	0.0	0.0	4.28534E-03	2.54736E-03	9.05660E-04	5.29677E-05	7.09864E-07	1.37042E-08
15	0.0	0.0	0.0	2.06505E-03	7.91634E-04	1.50642E-04	7.81983E-07	9.41979E-08
16	0.0	0.0	0.0	0.0	8.99551E-04	1.69644E-04	6.91364E-06	1.04651E-07
17	0.0	0.0	0.0	0.0	0.0	1.21786E-04	3.19349E-05	9.85048E-07
18	0.0	0.0	0.0	0.0	0.0	0.0	1.51054E-06	4.80969E-06
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.37445E-07
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21 THRU	43 SAME AS ABOVE							

POS.	GRP. 17	GRP. 18	GRP. 19	GRP. 20	GRP. 21	GRP. 22	GRP. 23	GRP. 24
1	-7.69754E-03	-9.32158E-03	-1.79976E-02	-2.05362E-02	-2.60101E-02	-8.82412E-02	-6.78152E-01	-1.07220E 00
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	-2.02047E 00	-1.41463E 00	-1.56528E 00	-1.03341E 00	-8.07333E-01	-6.64271E-01	-1.04633E-01	-2.14289E-01
4	1.79227E 00	1.21499E 00	1.38367E 00	8.81565E-01	6.83982E-01	5.75423E-01	2.82297E-03	5.83569E-03
5	2.16983E-01	1.92310E-01	1.73970E-01	1.47248E-01	1.20061E-01	8.71141E-02	1.10939E-02	3.48285E-03
6	0.0	0.0	0.0	0.0	0.0	0.0	6.42678E-03	7.97718E-03
7	0.0	0.0	0.0	0.0	0.0	0.0	4.71966E-03	2.26301E-03
8	0.0	0.0	0.0	0.0	0.0	0.0	3.74151E-03	1.65981E-03
9	0.0	0.0	0.0	0.0	0.0	0.0	1.85761E-03	1.31404E-03
10	0.0	0.0	0.0	0.0	0.0	0.0	1.35375E-03	6.51180E-04
11	0.0	0.0	0.0	0.0	0.0	0.0	9.10328E-04	4.73624E-04
12	0.0	0.0	0.0	0.0	0.0	0.0	4.08263E-04	3.16974E-04
13	8.46387E-10	0.0	0.0	0.0	0.0	0.0	2.79064E-04	1.39223E-04
14	0.0	1.89115E-10	0.0	0.0	0.0	0.0	1.29510E-04	5.94748E-05
15	1.59051E-09	0.0	7.24566E-11	0.0	0.0	0.0	8.59108E-05	2.87678E-06
16	9.01305E-09	2.90877E-10	0.0	1.67661E-11	0.0	0.0	5.54947E-05	0.0
17	1.04352E-08	1.52307E-09	0.0	0.0	1.99222E-12	0.0	1.84274E-05	0.0
18	1.18487E-07	8.02316E-10	0.0	0.0	0.0	0.0	2.80757E-06	0.0
19	6.26111E-07	2.56174E-08	3.05041E-10	0.0	0.0	0.0	5.82186E-06	0.0
20	2.45206E-08	1.43586E-07	9.80867E-09	6.99536E-11	0.0	0.0	4.79492E-06	0.0

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21	0.0	0.0	5.46954E-08	0.0	8.25586E-12	0.0	4.94156E-07	0.0
22	0.0	0.0	0.0	1.30593E-08	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	3.78835E-09	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	5.96433E-06	1.37584E-03
25	0.0	0.0	0.0	0.0	0.0	0.0	5.41534E-04	6.45293E-03
26	0.0	0.0	0.0	0.0	0.0	0.0	2.63498E-03	1.57566E-02
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.33331E-02
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 THRU 43 SAME AS ABOVE								

POS.	GRP. 25	GRP. 26	GRP. 27	GRP. 28	GRP. 29	GRP. 30	GRP. 31	GRP. 32
1	-2.07821E 00	-5.42225E-01	-3.60219E-01	-1.05687E-01	-1.01609E-01	-4.60114E-02	-3.42086E-02	-2.39712E-02
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	-5.48362E-01	-1.91721E-01	-1.72574E-01	-6.76071E-02	-8.30662E-02	-4.84732E-02	-4.64222E-02	-4.46951E-02
4	2.05893E-02	6.88257E-03	8.70589E-03	2.53942E-03	4.14085E-03	2.31808E-03	2.99038E-03	4.31495E-03
5	8.94062E-03	2.10872E-02	9.92791E-03	6.65000E-03	3.95237E-03	4.45308E-03	3.66607E-03	4.66742E-03
6	2.63992E-03	4.42497E-03	1.45033E-02	3.61410E-03	4.98015E-03	2.07710E-03	3.36757E-03	2.73459E-03
7	5.09300E-02	1.39997E-03	3.24342E-03	5.43828E-03	2.85944E-03	2.72022E-03	1.67915E-03	2.65246E-03
8	1.44265E-02	5.05195E-03	1.09024E-03	1.28379E-03	4.40126E-03	1.64278E-03	2.28337E-03	1.42074E-03
9	1.05619E-02	1.42791E-03	4.69274E-03	4.53138E-04	1.07826E-03	2.57078E-03	1.43768E-03	2.01360E-03
10	8.34550E-03	1.04276E-03	1.32323E-03	7.28880E-04	3.92375E-04	6.50099E-04	2.27770E-03	1.31883E-03
11	4.12538E-03	8.21690E-04	9.63475E-04	2.04923E-04	5.63400E-06	2.42452E-04	5.90096E-04	2.11147E-03
12	2.99419E-03	4.04710E-04	7.56771E-04	1.48690E-04	1.58052E-06	1.21244E-03	2.23916E-04	5.58839E-04
13	1.99762E-03	2.92858E-04	3.71186E-04	1.16355E-04	1.14378E-06	3.39414E-04	0.0	2.14999E-04
14	8.75341E-04	1.94611E-04	2.67671E-04	5.67915E-05	8.92541E-07	2.45008E-04	0.0	3.02904E-06
15	3.75126E-04	8.49473E-05	1.77051E-04	4.07839E-05	4.33986E-07	1.90662E-04	0.0	8.45701E-07
16	1.85374E-05	3.65920E-05	7.69471E-05	2.68248E-05	3.10708E-07	9.23726E-05	0.0	6.08625E-07
17	0.0	1.86728E-06	3.33616E-05	1.15997E-05	2.03489[illegible]	6.59341E-05	0.0	4.72043E-07
18	0.0	0.0	1.76978E-06	5.07356E-06	8.76635E[illegible]	4.30019E-05	0.0	2.27719E-07
19	0.0	0.0	0.0	2.82758E-07	3.86419E-08	1.84641E-05	0.0	1.61969E-07
20	0.0	0.0	0.0	0.0	2.24206E-09	8.21009E-06	0.0	1.05108E-07
21	0.0	0.0	0.0	0.0	0.0	4.97172E-07	0.0	4.49845E-08
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.02237E-08
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.31035E-09
24	1.18733E-03	3.34611E-08	0.0	0.0	2.31270E-09	0.0	0.0	0.0
25	1.12576E-02	1.05062E-03	3.37327E-05	0.0	1.26642E-05	0.0	0.0	0.0
26	1.37123E-02	3.65922E-03	1.50931E-04	0.0	9.03303E-05	0.0	0.0	0.0
27	1.36139E-02	2.67810E-03	7.84907E-04	7.44093E-05	9.16261E-04	0.0	0.0	0.0
28	1.57187E-02	4.23273E-03	1.75918E-03	3.76951E-04	2.25222E-03	0.0	0.0	0.0
29	0.0	5.53346E-03	2.99406E-03	3.21309E-04	2.18192E-03	0.0	1.38956E-04	0.0
30	0.0	0.0	3.38301E-03	3.34580E-04	1.24612E-03	0.0	4.89796E-04	0.0
31	0.0	0.0	0.0	3.22362E-04	1.05645E-03	4.41154E-07	5.16043E-04	2.89173E-07
32	0.0	0.0	0.0	0.0	7.26571E-04	7.18317E-06	2.23161E-04	3.76969E-06
33	0.0	0.0	0.0	0.0	0.0	5.32879E-06	1.54758E-04	1.27323E-05
34	0.0	0.0	0.0	0.0	0.0	0.0	6.85250E-05	1.58077E-05
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.43732E-06
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37 THRU 43 SAME AS ABOVE								

POS.	GRP. 33	GRP. 34	GRP. 35	GRP. 36	GRP. 37	GRP. 38	GRP. 39	GRP. 40
1	-1.07732E-02	-8.37982E-03	-8.37487E-03	-2.67812E-03	-2.37811E-03	-2.71744E-03	-8.66145E-04	-2.13732E-0[illegible]
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	-2.82001E-02	-3.08147E-02	-4.92975E-02	-2.63310E-02	-3.87927E-02	-9.79541E-02	-8.07098E-02	-1.84939E-03
4	2.65484E-03	4.39321E-03	1.22515E-02	6.26885E-03	1.49328E-02	7.20522E-02	6.80951E-02	5.65[illegible]53E-04
5	4.21974E-03	4.07046E-03	6.16426E-03	8.46481E-03	8.20073E-03	1.56313E-02	1.07876E-02	1.2[illegible]387E-03
6	2.13213E-03	3.12849E-03	2.77999E-03	2.10088E-03	6.66855E-03	3.84621E-03	0.0	0.0
7	1.33644E-03	1.73577E-03	2.49091E-03	1.16497E-03	2.34195E-03	2.37675E-03	0.0	0.0
8	1.36934E-03	1.16004E-03	1.58316E-03	1.18555E-03	1.41487E-03	3.31628E-04	0.0	0.0
9	7.78371E-04	1.24432E-03	1.18771E-03	7.89806E-04	1.30048E-03	2.77399E-05	0.0	0.0
10	1.13900E-03	7.36234E-04	1.45698E-03	5.75247E-04	7.52187E-04	0.0	0.0	0.0
11	7.66760E-04	1.10004E-03	1.02664E-03	6.44977E-04	4.91578E-04	0.0	0.0	0.0
12	1.23371E-03	7.52159E-04	1.95730E-03	3.94830E-04	4.98727E-04	0.0	0.0	0.0
13	3.31340E-04	1.21260E-03	1.83878E-03	5.93273E-04	2.79968E-04	0.0	0.0	0.0
14	1.28595E-04	3.28094E-04	4.12968E-03	4.06175E-04	3.84586E-04	0.0	0.0	0.0
15	1.02582E-06	1.27810E-04	1.56104E-03	6.46409E-04	2.42420E-04	0.0	0.0	0.0
16	2.86283E-07	0.0	8.56316E-04	1.74963E-04	3.60907E-04	0.0	0.0	0.0

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17	2.05891E-07	0.0	1.51421E-06	6.79922E-05	9.28096E-05	0.0	0.0	0.0
18	1.59600E-07	0.0	4.22571E-07	0.0	3.46799E-05	0.0	0.0	0.0
19	7.69317E-08	0.0	3.03902E-07	0.0	0.0	0.0	0.0	0.0
20	5.46878E-08	0.0	2.35574E-07	0.0	0.0	0.0	0.0	0.0
21	3.54568E-08	0.0	1.13551E-07	0.0	0.0	0.0	0.0	0.0
22	1.5[illegible]718E-08	0.0	8.07183E-08	0.0	0.0	0.0	0.0	0.0
23	6.87[illegible]05E-09	0.0	5.23320E-08	0.0	0.0	0.0	0.0	0.0
24	4.52799E-10	0.0	2.24071E-08	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	1.01912E-09	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	6.80023E-10	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28 THRU 32 SAME AS ABOVE								
33	0.0	6.41132E-07	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	3.97977E-05	0.0	0.0	0.0	0.0	0.0	0.0
35	0.0	3.89508E-05	2.17401E-05	0.0	0.0	0.0	0.0	0.0
36	0.0	2.42427E-05	2.09267E-05	0.0	0.0	0.0	0.0	0.0
37	0.0	1.29717E-05	1.22884E-05	0.0	0.0	0.0	0.0	0.0
38	0.0	0.0	4.52867E-06	0.0	0.0	6.67191E-08	0.0	0.0
39	0.0	0.0	0.0	0.0	0.0	6.87072E-07	0.0	0.0
40	0.0	0.0	0.0	0.0	0.0	1.43161E-06	0.0	0.0
41	0.0	0.0	0.0	0.0	0.0	7.91304E-07	0.0	0.0
42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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SENSITIVITY MATRIX FOR CROSS SECTION SET 1 IN SN FORMAT

P(1)

POS.	GRP. 1	GRP. 2	GRP. 3	GRP. 4	GRP. 5	GRP. 6	GRP. 7	GRP. 8
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	1.22635E-01	1.00012E-01	9.57026E-02	7.93353E-02	1.04189E-01	5.75176E-02	2.22691E-02	3.85373E-02
5	0.0	4.68043E-03	-7.43893E-03	-1.50359E-02	-1.31244E-02	-2.36131E-02	-1.04598E-02	-2.03250E-02
6	0.0	0.0	-3.20763E-03	-3.44027E-03	-4.88938E-04	-3.35732E-04	-3.94234E-03	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	THRU 43 SAME AS ABOVE							

POS.	GRP. 9	GRP. 10	GRP. 11	GRP. 12	GRP. 13	GRP. 14	GRP. 15	GRP. 16
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	8.52344E-03	6.14219E-02	7.02138E-02	5.35780E-02	1.69220E-02	6.08659E-03	1.24002E-03	8.61620E-04
5	4.86306E-03	-1.29708E-03	-1.79300E-02	-1.22497E-02	-4.68500E-03	-1.47377E-03	-4.86350E-04	-2.94710E-04
6	-5.79121E-[illegible]	-3.29690E-02	-1.24405E-03	0.0	0.0	0.0	0.0	0.0
7	0.0	-1.13123E-03	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	THRU 43 SAME AS ABOVE							

POS.	GRP. 17	GRP. 18	GRP. 19	GRP. 20	GRP. 21	GRP. 22	GRP. 23	GRP. 24
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	4.82568E-04	3.42651E-04	3.19484E-04	2.12762E-04	1.50832E-04	0.0	1.67812E-03	2.79739E-03
5	-2.04497E-04	-1.61105E-04	-1.38324E-04	-1.09478E-04	-8.40548E-05	-4.87018E-[illegible]	0.0	2.13328E-03
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	THRU 43 SAME AS ABOVE							

POS.	GRP. 25	GRP. 26	GRP. 27	GRP. 28	GRP. 29	GRP. 30	GRP. 31	GRP. 32
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	1.35748E-02	4.70650E-03	5.91258E-03	1.63897E-03	2.50950E-03	1.30576E-03	1.48508E-03	1.78567E-03
5	6.00085E-03	1.42092E-02	6.62692E-03	4.28256E-03	2.36107E-03	2.44469E-03	1.81752E-03	1.92285E-03
6	1.64570E-03	2.98375E-03	9.57536E-03	2.24385E-03	2.94218E-03	1.09150E-03	1.59357E-03	1.08587E-03
7	0.0	8.68316E-04	2.12290E-03	3.38369E-03	1.62408E-03	1.41540E-03	7.55170E-04	9.98683E-04
8	0.0	0.0	6.51037E-04	7.83345E-04	2.52329E-03	8.19393E-04	1.01474E-03	5.04685E-04
9	0.0	0.0	0.0	2.50708E-04	6.01212E-04	1.30146E-03	6.10396E-04	7.02071E-04
10	0.0	0.0	0.0	0.0	1.97843E-04	3.17323E-04	9.83290E-04	4.36604E-04
11	0.0	0.0	0.0	0.0	0.0	1.06887E-04	2.43724E-04	7.08994E-04
12	0.0	0.0	0.0	0.0	0.0	0.0	8.35085E-05	1.77936E-04
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.17773E-05
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	THRU 43 SAME AS ABOVE							

POS.	GRP. 33	GRP. 34	GRP. 35	GRP. 36	GRP. 37	GRP. 38	GRP. 39	GRP. 40
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	8.69763E-04	1.07100E-03	1.46493E-03	3.68768E-04	1.39110E-04	5.04522E-04	1.27716E-04	2.20439E-10
5	1.39542E-03	1.04018E-03	9.87517E-04	5.77454E-04	2.02621E-04	-2.14876E-05	-6.32290E-05	1.02895E-06
6	6.58155E-04	7.45210E-04	3.87956E-04	1.03533E-04	-3.15434E-05	-9.32544E-05	0.0	0.0
7	3.92864E-04	3.73791E-04	2.87035E-04	2.32013E-05	-1.37302E-04	-1.32356E-04	0.0	0.0
8	3.77251E-04	2.31883E-04	1.40170E-04	-1.06593E-05	-1.38244E-04	-3.67077E-05	0.0	0.0
9	2.00439E-04	2.27190E-04	8.07823E-05	-2.74719E-05	-1.59971E-04	-3.87948E-06	0.0	0.0
10	2.84397E-04	1.22907E-04	7.01540E-05	-3.03928E-05	-1.05906E-04	0.0	0.0	0.0
11	1.79887E-04	1.73312E-04	3.26428E-05	-4.32741E-05	-7.54623E-05	0.0	0.0	0.0
12	2.91176E-04	1.08556E-04	3.62819E-05	-3.10746E-05	-8.03190E-05	0.0	0.0	0.0
13	7.33628E-05	1.72208E-04	1.63141E-05	-5.44638E-05	-4.68220E-05	0.0	0.0	0.0
14	2.56201E-05	4.28566E-05	1.68926E-05	-4.09642E-05	-6.80780E-05	0.0	0.0	0.0
15	0.0	1.48402E-05	2.29569E-06	-7.30297E-05	-4.38696E-05	0.0	0.0	0.0
16	0.0	0.0	2.63943E-07	-2.01162E-05	-6.96487E-05	0.0	0.0	0.0

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17	0.0	0.0	0.0	-7.52083E-06	-1.76132E-05	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	-6.18928E-06	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20 THRU	43 SAME AS ABOVE							

ORNL-DWG 73-3547

SENSITIVITY MATRIX FOR CROSS SECTION SET 1 IN SN FORMAT

P(2)

POS.	GRP. 1	GRP. 2	GRP. 3	GRP. 4	GRP. 5	GRP. 6	GRP. 7	GRP. 8
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	1.47486E-02	9.92430E-03	8.75768E-03	6.65697E-03	8.25313E-03	4.45380E-03	1.33095E-03	2.12382E-03
5	0.0	-1.09773E-03	-1.29542E-03	-6.25847E-04	-2.26729E-04	2.72735E-04	3.16584E-04	5.18844E-04
6	0.0	0.0	3.52106E-04	3.58910E-04	6.16353E-05	3.57249E-05	3.16197E-04	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	THRU 43 SAME AS ABOVE							

POS.	GRP. 9	GRP. 10	GRP. 11	GRP. 12	GRP. 13	GRP. 14	GRP. 15	GRP. 16
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	9.95259E-04	1.88048E-03	1.72556E-03	1.12670E-03	8.67528E-05	1.35696E-06	1.71808E-07	8.65892E-08
5	-6.35271E-04	-3.58077E-04	5.03751E-05	1.76887E-04	-2.86545E-05	-9.95297E-07	-1.61292E-07	-5.58912E-08
6	4.47010E-04	6.93437E-04	1.09389E-04	0.0	0.0	0.0	0.0	0.0
7	0.0	1.05830E-04	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	THRU 43 SAME AS ABOVE							

POS.	GRP. 17	GRP. 18	GRP. 19	GRP. 20	GRP. 21	GRP. 22	GRP. 23	GRP. 24
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	3.92688E-08	2.79133E-08	1.90948E-08	9.72166E-09	-2.11821E-09	0.0	-4.72702E-05	1.01803E-04
5	-2.97125E-08	-1.97466E-08	-1.38774E-08	-7.97483E-09	1.76763E-09	8.59388E-09	0.0	-1.81242E-05
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	THRU 43 SAME AS ABOVE							

POS.	GRP. 25	GRP. 26	GRP. 27	GRP. 28	GRP. 29	GRP. 30	GRP. 31	GRP. 32
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	7.84650E-04	2.74075E-04	4.96586E-04	1.37691E-04	2.96706E-04	1.24905E-04	1.24236E-04	1.08261E-04
5	2.95318E-04	1.13406E-03	4.95059E-04	4.02809E-04	1.93738E-04	2.35431E-04	1.42543E-04	1.12560E-04
6	2.25408E-05	2.08552E-04	8.85977E-04	1.82993E-04	2.59003E-04	6.34766E-05	1.17894E-04	5.28948E-05
7	0.0	3.01783E-05	1.74723E-04	3.27389E-04	1.22834E-04	8.98141E-05	3.15284E-05	4.29466E-05
8	0.0	0.0	3.17523E-05	6.74175E-05	2.23765E-04	4.28181E-05	4.55213E-05	1.02042E-05
9	0.0	0.0	0.0	1.38490E-05	4.67097E-05	8.42307E-05	2.14358E-05	1.43288E-05
10	0.0	0.0	0.0	0.0	9.97125E-06	1.69270E-05	4.32024E-05	5.83148E-06
11	0.0	0.0	0.0	0.0	0.0	3.28916E-06	8.23821E-06	1.10937E-05
12	0.0	0.0	0.0	0.0	0.0	0.0	1.48683E-06	1.62536E-06
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.99439E-07
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	THRU 43 SAME AS ABOVE							

POS.	GRP. 33	GRP. 34	GRP. 35	GRP. 36	GRP. 37	GRP. 38	GRP. 39	GRP. 40
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	THRU 3 SAME AS ABOVE							
4	3.57564E-05	2.95384E-05	2.52119E-05	4.53348E-06	-9.23648E-07	5.53374E-07	-9.14163E-07	-1.25569E-08
5	4.90227E-05	2.24242E-05	8.67415E-06	1.77278E-06	-7.24211E-07	1.54780E-07	-1.65686E-07	-3.99321E-07
6	1.71193E-05	8.55984E-06	-5.08673E-07	-1.86974E-06	-3.90632E-06	1.68052E-07	0.0	0.0
7	6.99316E-06	1.16483E-06	-1.84689E-06	-6.85192E-07	-4.83924E-07	8.75634E-07	0.0	0.0
8	4.53214E-06	-6.33354E-07	-1.32814E-06	1.42698E-07	-2.58017E-08	9.19511E-08	0.0	0.0
9	4.54787E-07	-1.88271E-06	-5.33617E-07	5.11997E-07	-4.54043E-07	-2.57512E-08	0.0	0.0
10	-3.59565E-09	2.51111E-08	-6.73048E-07	6.77882E-07	-6.60325E-07	0.0	0.0	0.0
11	-4.40173E-07	-9.22812E-07	2.77041E-06	7.64366E-07	-7.45907E-07	0.0	0.0	0.0
12	-2.79629E-06	-8.03302E-06	3.16110E-06	1.38802E-06	-9.63588E-07	0.0	0.0	0.0
13	-6.12331E-07	-4.33943E-06	3.19183E-06	1.64178E-06	-1.21225E-06	0.0	0.0	0.0
14	-2.40802E-08	-3.76064E-07	1.22400E-08	1.22790E-06	-1.73685E-06	0.0	0.0	0.0
15	0.0	2.99032E-07	1.13755E-06	7.70687E-07	-1.38018E-06	0.0	0.0	0.0
16	0.0	0.0	8.99335E-07	4.01722E-07	-1.35875E-06	0.0	0.0	0.0

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17	0.0	0.0	0.0	2.11090E-07	-5.71079E-07	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	-2.80029E-07	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

20 THRU 43 SAME AS ABOVE

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SENSITIVITY MATRIX FOR CROSS SECTION SET 1 IN SN FORMAT

P(3)

POS.	GRP. 1	GRP. 2	GRP. 3	GRP. 4	GRP. 5	GRP. 6	GRP. 7	GRP. 8
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 THRU 3 SAME AS ABOVE								
4	8.05509E-04	4.23108E-04	1.51817E-04	1.74591E-04	1.84955E-04	1.15152E-04	3.52947E-05	3.94912E-05
5	0.0	1.49325E-05	2.51391E-05	1.57345E-05	2.80415E-05	2.67567E-05	-3.35688E-07	3.56435E-06
6	0.0	0.0	-1.13130E-05	-1.07354E-05	-1.81719E-06	-1.06692E-06	-7.63035E-06	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8 THRU 43 SAME AS ABOVE								

POS.	GRP. 9	GRP. 10	GRP. 11	GRP. 12	GRP. 13	GRP. 14	GRP. 15	GRP. 16
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 THRU 3 SAME AS ABOVE								
4	2.48352E-05	3.75024E-05	2.11479E-05	2.18827E-06	1.46640E-07	-1.11859E-10	2.29027E-12	2.02979E-12
5	-9.66322E-07	-1.29822E-06	-2.85803E-06	-5.48590E-06	-3.31155E-07	-3.12598E-10	-3.18574E-11	-8.38593E-12
6	-7.64610E-06	1.51221E-06	-4.56125E-06	0.0	0.0	0.0	0.0	0.0
7	0.0	-4.39391E-06	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9 THRU 43 SAME AS ABOVE								

POS.	GRP. 17	GRP. 18	GRP. 19	GRP. 20	GRP. 21	GRP. 22	GRP. 23	GRP. 24
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 THRU 3 SAME AS ABOVE								
4	1.22022E-12	1.39785E-12	1.15004E-12	1.11944E-12	1.96990E-12	0.0	-9.95214E-05	-2.35332E-04
5	-5.67301E-12	-2.18844E-12	-2.61992E-12	-1.46212E-12	-5.42805E-12	-6.97954E-12	0.0	-1.20840E-04
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 THRU 43 SAME AS ABOVE								

POS.	GRP. 25	GRP. 26	GRP. 27	GRP. 28	GRP. 29	GRP. 30	GRP. 31	GRP. 32
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 THRU 3 SAME AS ABOVE								
4	-7.52368E-04	-2.52015E-04	-2.45615E-04	-5.30442E-05	-3.67628E-05	-1.14820E-05	-2.51824E-06	2.98875E-06
5	-3.31159E-04	-6.49261E-04	-2.66721E-04	-1.20292E-04	-4.90325E-05	-1.85387E-05	-5.08469E-06	2.28174E-06
6	-8.16552E-05	-1.28285E-04	-3.04785E-04	-5.47494E-05	-4.67843E-05	-1.15022E-05	-2.82953E-06	4.16432E-07
7	0.0	-3.39515E-05	-6.20459E-05	-6.21490E-05	-2.12454E-05	-1.00095E-05	-2.35120E-06	1.26790E-07
8	0.0	0.0	-1.74244E-05	-1.26226E-05	-2.26921E-05	-4.05208E-06	-1.25094E-06	1.69657E-07
9	0.0	0.0	0.0	-3.70840E-06	-4.29568E-06	-3.23140E-06	8.37885E-08	3.30998E-07
10	0.0	0.0	0.0	0.0	-1.23732E-06	-3.65304E-07	9.98130E-07	4.80621E-07
11	0.0	0.0	0.0	0.0	0.0	-2.12481E-08	4.03020E-07	4.05955E-07
12	0.0	0.0	0.0	0.0	0.0	0.0	2.47146E-07	4.54893E-08
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.39031E-07
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15 THRU 43 SAME AS ABOVE								

POS.	GRP. 33	GRP. 34	GRP. 35	GRP. 36	GRP. 37	GRP. 38	GRP. 39	GRP. 40
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 THRU 3 SAME AS ABOVE								
4	1.83552E-06	5.72138E-07	-1.24433E-07	5.00556E-07	5.47978E-08	3.76365E-08	6.12386E-09	-1.43351E-12
5	2.42984E-06	8.17503E-07	4.95129E-09	7.42648E-08	-2.82267E-07	-9.14621E-09	-4.70342E-09	-2.38645E-09
6	5.85696E-08	-6.79227E-07	-5.76236E-07	4.15494E-08	-1.56600E-08	5.71719E-08	0.0	0.0
7	-5.23600E-07	-1.42430E-06	-1.45742E-06	-5.69968E-08	-6.28434E-08	9.86370E-09	0.0	0.0
8	-1.09241E-06	-1.40762E-06	-1.34854E-06	6.60872E-08	6.44912E-08	2.37817E-08	0.0	0.0
9	-4.22442E-07	-1.93970E-06	-1.03396E-06	2.68656E-07	1.34093E-07	-4.23956E-09	0.0	0.0
10	-1.01655E-06	-9.67193E-07	-1.10382E-06	3.58235E-07	9.01300E-08	0.0	0.0	0.0
11	-6.74452E-07	-1.78281E-06	-5.20565E-07	5.71584E-07	3.80799E-08	0.0	0.0	0.0
12	-1.45905E-06	-1.19166E-06	-6.74318E-07	4.04060E-07	-4.67764E-09	0.0	0.0	0.0
13	-4.77390E-07	-2.10038E-06	-3.19282E-07	7.60003E-07	-3.31836E-08	0.0	0.0	0.0
14	-1.01939E-07	-6.28250E-07	-3.37178E-07	5.67344E-07	-1.03328E-07	0.0	0.0	0.0
15	0.0	-1.76556E-07	-5.35374E-08	9.68823E-07	-1.01777E-07	0.0	0.0	0.0
16	0.0	0.0	-5.76131E-09	2.93636E-07	-1.96655E-07	0.0	0.0	0.0

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17	0.0	0.0	0.0	9.76543E-08	-6.56764E-08	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	-2.40528E-08	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20 THRU 43 SAME AS ABOVE								

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SENSITIVITY MATRIX FOR CROSS SECTION SET 1 SUMMED OVER P(L),IN SN FORMAT

POS.	GRP. 1	GRP. 2	GRP. 3	GRP. 4	GRP. 5	GRP. 6	GRP. 7	GRP. 8
1	-2.09532E-01	-1.80822E-01	-1.42706E-01	-1.45004E-01	-1.59947E-01	-1.76258E-01	-1.54448E-01	-1.21620E-01
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	-1.32867E 00	-1.18261E 00	-1.16924E 00	-1.16035E 00	-1.36331E 00	-9.40793E-01	-1.01870E 00	-1.05227E 00
4	5.48032E-01	4.73503E-01	4.55948E-01	4.64692E-01	5.99325E-01	3.86872E-01	4.73208E-01	3.08779E-01
5	0.0	1.65580E-01	1.70890E-01	1.73415E-01	1.91840E-01	2.19404E-01	2.56994E-01	3.12357E-01
6	0.0	0.0	1.38203E-02	1.37751E-02	3.42574E-03	2.69867E-03	2.48046E-02	0.0
7	0.0	0.0	0.0	2.89512E-02	1.44600E-02	4.50142E-03	6.01004E-03	1.97883E-03
8	0.0	0.0	0.0	0.0	3.19706E-02	1.34968E-02	1.07514E-02	8.67178E-03
9	0.0	0.0	0.0	0.0	0.0	1.18323E-02	1.68367E-02	1.48151E-02
10	0.0	0.0	0.0	0.0	0.0	0.0	1.33998E-02	7.20218E-03
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00064E-02
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	THRU 43 SAME AS ABOVE							

POS.	GRP. 9	GRP. 10	GRP. 11	GRP. 12	GRP. 13	GRP. 14	GRP. 15	GRP. 16
1	-2.26263E-02	-7.54598E-02	-9.10115E-02	-6.69040E-02	-1.14264E-02	-3.91081E-03	-3.33075E-03	-6.45257E-03
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	-3.63041E-01	-1.60745E 00	-3.30356E 00	-4.84142E 00	-7.27623E 00	-1.17617E 01	-3.87913E 00	-3.40213E 00
4	4.12677E-02	6.75106E-01	2.24630E 00	3.62120E 00	6.47091E 00	1.12062E 01	3.56188E 00	3.12483E 00
5	1.20064E-01	1.59739E-01	4.51868E-01	4.66145E-01	3.96728E-01	3.01023E-01	2.68418E-01	2.51524E-01
6	3.31853E-02	2.49928E-01	5.78531E-03	0.0	0.0	0.0	0.0	0.0
7	0.0	6.61521E-03	0.0	0.0	0.0	0.0	0.0	0.0
8	4.33062E-04	1.05389E-03	2.33425E-04	0.0	0.0	0.0	0.0	0.0
9	2.73900E-03	6.25076E-04	8.87966E-04	2.67930E-04	3.95014E-05	0.0	0.0	0.0
10	3.25490E-03	1.35023E-02	9.30178E-03	6.11097E-04	1.97250E-05	3.27108E-06	0.0	0.0
11	2.09889E-03	9.97763E-03	8.90210E-03	5.32025E-03	1.27525E-03	0.0	4.84043E-08	0.0
12	1.96566E-03	7.13969E-03	5.95776E-03	5.31705E-03	5.88987E-04	3.53741E-05	0.0	6.94354E-09
13	0.0	5.47854E-03	6.78978E-03	2.10032E-03	1.13640E-03	6.64901E-05	1.12634E-07	0.0
14	0.0	0.0	4.28534E-03	2.54736E-03	9.05660E-04	5.29677E-05	7.09864E-07	1.37042E-08
15	0.0	0.0	0.0	2.06505E-03	7.91634E-04	1.50642E-04	7.81983E-07	9.41079E-08
16	0.0	0.0	0.0	0.0	8.99551E-04	1.69644E-04	6.91364E-06	1.04651E-07
17	0.0	0.0	0.0	0.0	0.0	1.21785E-04	3.19349E-05	9.85048E-07
18	0.0	0.0	0.0	0.0	0.0	0.0	1.51054E-06	4.80869E-06
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.37445E-07
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	THRU 43 SAME AS ABOVE							

POS.	GRP. 17	GRP. 18	GRP. 19	GRP. 20	GRP. 21	GRP. 22	GRP. 23	GRP. 24
1	-7.69754E-03	-9.32158E-03	-1.79976E-02	-2.05362E-02	-2.60101E-02	-8.82412E-02	-6.78152E-01	-1.07220E 00
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	-2.02047E 00	-1.41463E 00	-1.56528E 00	-1.03341E 00	-8.07333E-01	-6.64271E-01	-1.04633E-01	-2.14289E-01
4	1.79275E 00	1.21533E 00	1.38399E 00	8.81778E-01	6.84133E-01	5.75423E-01	4.35429E-03	9.49954E-03
5	2.16778E-01	1.92149E-01	1.73831E-01	1.47139E-01	1.19977E-01	8.70653E-02	1.10939E-02	5.47716E-03
6	0.0	0.0	0.0	0.0	0.0	0.0	6.42678E-03	7.97718E-03
7	0.0	0.0	0.0	0.0	0.0	0.0	4.71966E-03	2.26301E-03
8	0.0	0.0	0.0	0.0	0.0	0.0	3.74151E-03	1.65981E-03
9	0.0	0.0	0.0	0.0	0.0	0.0	1.85761E-03	1.31404E-03
10	0.0	0.0	0.0	0.0	0.0	0.0	1.35375E-03	6.51180E-04
11	0.0	0.0	0.0	0.0	0.0	0.0	9.10328E-04	4.73624E-04
12	0.0	0.0	0.0	0.0	0.0	0.0	4.08263E-04	3.16874E-04
13	8.46387E-10	0.0	0.0	0.0	0.0	0.0	2.79064E-04	1.39223E-04
14	0.0	1.89115E-10	0.0	0.0	0.0	0.0	1.29510E-04	5.94748E-05
15	1.59051E-09	0.0	7.24566E-11	0.0	0.0	0.0	8.59108E-05	2.87678E-06
16	9.01305E-09	2.90877E-10	0.0	1.67661E-11	0.0	0.0	5.54947E-05	0.0
17	1.04352E-08	1.52307E-09	0.0	0.0	1.99222E-12	0.0	1.84274E-05	0.0
18	1.18487E-07	8.02316E-10	0.0	0.0	0.0	0.0	2.80757E-06	0.0
19	6.26111E-07	2.56174E-08	3.05041E-10	0.0	0.0	0.0	5.82186E-06	0.0
20	2.45206E-08	1.43586E-07	9.80867E-09	6.99536E-11	0.0	0.0	4.79492E-06	0.0
21	0.0	0.0	5.46954E-08	0.0	8.25586E-12	0.0	4.94156E-07	0.0
22	0.0	0.0	0.0	1.30593E-08	0.0	0.0	0.0	0.0

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23	0.0	0.0	0.0	0.0	3.78835E-09	0.0	0.0	0.0
24	0.0	0.0	0.0	0.0	0.0	0.0	5.96433E-06	1.37584E-03
25	0.0	0.0	0.0	0.0	0.0	0.0	5.41534E-04	6.45293E-03
26	0.0	0.0	0.0	0.0	0.0	0.0	2.63498E-03	1.57566E-02
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.33331E-02
28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29 THRU	43 SAME AS ABOVE							

POS.	GRP. 25	GRP. 26	GRP. 27	GRP. 28	GRP. 29	GRP. 30	GRP. 31	GRP. 32
1	-2.07821E 00	-5.42225E-01	-3.60219E-01	-1.05687E-01	-1.01609E-01	-4.60114E-02	-3.42086E-02	-2.39212E-02
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	-5.48362E-01	-1.91721E-01	-1.72574E-01	-6.76071E-02	-8.30662E-02	-4.84732E-02	-4.64222E-02	-4.46951E-02
4	3.41963E-02	1.16111E-02	1.48694E-02	4.26304E-03	6.91029E-03	3.73726E-03	4.59717E-03	6.21187E-03
5	1.49056E-02	3.57812E-02	1.67832E-02	1.12151E-02	6.45814E-03	7.11466E-03	5.62104E-03	6.70511E-03
6	4.22650E-03	7.48898E-03	2.46598E-02	5.98618E-03	8.13455E-03	3.22057E-03	5.07620E-03	3.87377E-03
7	5.09300E-02	2.26451E-03	5.47900E-03	9.08721E-03	4.58511E-03	4.21543E-03	2.46349E-03	3.69422E-03
0	1.44265E-02	5.05195E-03	1.75561E-03	2.12193E-03	7.12562E-03	2.50094E-03	3.34238E-03	1.93580E-03
9	1.05629E-02	1.42791E-03	4.69274E-03	7.13986E-04	1.72188E-03	3.95323E-03	2.06960E-03	2.73033E-03
10	8.34550E-03	1.04276E-03	1.32323E-03	7.28880E-04	5.98951E-04	9.83977E-04	3.30519E-03	1.76175E-03
11	4.12538E-03	8.21690E-04	9.63475E-04	2.04923E-04	5.63400E-06	3.52606E-04	8.42461E-04	2.83197E-03
12	2.99419E-03	4.04710E-04	7.56771E-04	1.48690E-04	1.58052E-06	1.21244E-03	3.09158E-04	7.38455E-04
13	1.99762E-03	2.92858E-04	3.71186E-04	1.16355E-04	1.14378E-06	3.39414E-04	0.0	2.77115E-04
14	8.75341E-04	1.94611E-04	2.67671E-04	5.67915E-05	8.92541E-07	2.45008E-04	0.0	3.02904E-06
15	3.75126E-04	8.49473E-05	1.77051E-04	4.07839E-05	4.33986E-07	1.90662E-04	0.0	8.45701E-07
16	1.85374E-05	3.65920E-05	7.69471E-05	2.68248E-05	3.10708E-07	9.23726E-05	0.0	6.08625E-07
17	0.0	1.86728E-06	3.33616E-05	1.15997E-05	2.03489E-07	6.59341E-05	0.0	4.72043E-07
18	0.0	0.0	1.76978E-06	5.07356E-06	8.76635E-08	4.30019E-05	0.0	2.27719E-07
19	0.0	0.0	0.0	2.82758E-07	3.86419E-08	1.84641E-05	0.0	1.61969E-07
20	0.0	0.0	0.0	0.0	2.24206E-09	8.21009E-06	0.0	1.05108E-07
21	0.0	0.0	0.0	0.0	0.0	4.97172E-07	0.0	4.49945E-08
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.02937E-08
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.31035E-09
24	1.18733E-03	3.34611E-08	0.0	0.0	2.31270E-09	0.0	0.0	0.0
25	1.12576E-02	1.05062E-03	3.37327E-05	0.0	1.26642E-05	0.0	0.0	0.0
26	1.37123E-02	3.65922E-03	1.50931E-04	0.0	9.03303E-05	0.0	0.0	0.0
27	1.36139E-02	2.67810E-03	7.84907E-04	7.44093E-05	9.16261E-04	0.0	0.0	0.0
28	1.57187E-02	4.23273E-03	1.75918E-03	3.76951E-04	2.25222E-03	0.0	0.0	0.0
29	0.0	5.53346E-03	2.99406E-03	3.21309E-04	2.18192E-03	0.0	1.38956E-04	0.0
30	0.0	0.0	3.38301E-03	3.34580E-04	1.24612E-03	0.0	4.89796E-04	0.0
31	0.0	0.0	0.0	3.22362E-04	1.05645E-03	4.41154E-07	5.16043E-04	2.89173E-07
32	0.0	0.0	0.0	0.0	7.26571E-04	7.18317E-06	2.23161E-04	3.76969E-06
33	0.0	0.0	0.0	0.0	0.0	5.32879E-06	1.54758E-04	1.27323E-05
34	0.0	0.0	0.0	0.0	0.0	0.0	6.85250E-05	1.58077E-05
35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.43732E-06
36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37 THRU	43 SAME AS ABOVE							

POS.	GRP. 33	GRP. 34	GRP. 35	GRP. 36	GRP. 37	GRP. 38	GRP. 39	GRP. 40
1	-1.07732E-02	-8.37982E-03	-8.37487E-03	-2.67812E-03	-2.37811E-03	-2.71744E-03	-8.66145E-04	-2.13732E-05
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	-2.82001E-02	-3.08147E-02	-4.92975E-02	-2.63310E-02	-3.87927E-02	-9.79541E-02	-8.07098E-02	-1.84939E-03
4	3.56220E-03	5.49432E-03	1.37415E-02	6.64264E-03	1.50710E-02	7.25572E-02	6.82219E-02	5.65941E-04
5	5.66660E-03	5.13388E-03	7.16045E-03	9.04410E-03	8.40234E-03	1.56100E-02	1.07242E-02	1.28449E-03
6	2.80746E-03	3.88158E-03	3.16686E-03	2.20258E-03	5.63308E-03	3.75318E-03	0.0	0.0
7	1.73577E-03	2.10930E-03	2.77464E-03	1.18743E-03	2.20410E-03	2.24528E-03	0.0	0.0
8	1.75004E-03	1.38988E-03	1.72066E-03	1.17510E-03	1.27667E-03	2.95036E-04	0.0	0.0
9	9.78842E-04	1.46769E-03	1.26692E-03	7.63115E-04	1.14019E-03	2.38304E-05	0.0	0.0
10	1.42238E-03	8.58198E-04	1.52536E-03	5.45890E-04	6.45710E-04	0.0	0.0	0.0
11	9.45532E-04	1.27064E-03	1.06153E-03	6.03038E-04	4.15408E-04	0.0	0.0	0.0
12	1.52063E-03	8.59442E-04	1.99607E-03	3.65547E-04	4.17439E-04	0.0	0.0	0.0
13	4.03612E-04	1.37837E-03	1.85797E-03	5.41211E-04	2.31900E-04	0.0	0.0	0.0
14	1.54089E-04	3.69946E-04	4.14624E-03	3.67006E-04	3.14667E-04	0.0	0.0	0.0
15	1.02582E-06	1.42773E-04	1.56442E-03	5.75119E-04	1.97069E-04	0.0	0.0	0.0
16	2.86283E-07	0.0	8.57473E-04	1.55542E-04	2.89703E-04	0.0	0.0	0.0
17	2.05891E-07	0.0	1.51421E-06	6.07801E-05	7.45596E-05	0.0	0.0	0.0
18	1.59600E-07	0.0	4.22571E-07	0.0	2.81865E-05	0.0	0.0	0.0

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19	7.69317E-08	0.0	3.03902E-07	0.0	0.0	0.0	0.0	0.0
20	5.46878E-08	0.0	2.35574E-07	0.0	0.0	0.0	0.0	0.0
21	3.54568E-08	0.0	1.13551E-07	0.0	0.0	0.0	0.0	0.0
22	1.51718E-08	0.0	8.07183E-08	0.0	0.0	0.0	0.0	0.0
23	6.87705E-09	0.0	5.23320E-08	0.0	0.0	0.0	0.0	0.0
24	4.52799E-10	0.0	2.24071E-08	0.0	0.0	0.0	0.0	0.0
25	0.0	0.0	1.01912E-08	0.0	0.0	0.0	0.0	0.0
26	0.0	0.0	6.80023E-10	0.0	0.0	0.0	0.0	0.0
27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	THRU 32 SAME AS ABOVE							
33	0.0	6.41132E-07	0.0	0.0	0.0	0.0	0.0	0.0
34	0.0	3.97977E-05	0.0	0.0	0.0	0.0	0.0	0.0
35	0.0	3.89508E-05	2.17401E-05	0.0	0.0	0.0	0.0	0.0
36	0.0	2.42427E-05	2.09267E-05	0.0	0.0	0.0	0.0	0.0
37	0.0	1.29717E-05	1.22884E-05	0.0	0.0	0.0	0.0	0.0
38	0.0	0.0	4.52867E-06	0.0	0.0	6.67191E-08	0.0	0.0
39	0.0	0.0	0.0	0.0	0.0	6.87072E-07	0.0	0.0
40	0.0	0.0	0.0	0.0	0.0	1.43161E-06	0.0	0.0
41	0.0	0.0	0.0	0.0	0.0	7.91304E-07	0.0	0.0
42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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SENSITIVITY OF CROSS SECTION SET 1 BY GROUP AND ZONE
SUM OVER ZONES APPEARS AS ZONE NZONE+1

GRP.	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5
1	-3.88391E-04	-4.39582E-01	2.33549E-04	1.22535E-03	-4.38512E-01
2	-1.52713E-04	-4.16775E-01	3.33168E-04	2.46967E-03	-4.14125E-01
3	-1.13107E-04	-4.62663E-01	5.63455E-04	4.65193E-03	-4.57561E-01
4	-8.88623E-05	-4.38719E-01	2.25603E-04	4.00991E-03	-4.34572E-01
5	-6.17823E-05	-5.02029E-01	1.04251E-04	5.75351E-03	-4.96253E-01
6	-4.89399E-05	-2.92349E-01	-6.72092E-04	1.00742E-03	-2.91972E-01
7	-3.24944E-05	-1.91643E-01	-9.48003E-04	-9.47204E-05	-1.92718E-01
8	-5.02073E-05	-3.77368E-01	-2.89206E-06	3.98217E-03	-3.73439E-01
9	-1.59691E-05	-1.58497E-01	2.12446E-04	2.05429E-03	-1.56246E-01
10	-4.54076E-05	-4.85889E-01	1.37436E-04	5.33730E-03	-4.80459E-01
11	-3.62620E-05	-5.95226E-01	-1.38504E-03	5.58852E-03	-5.91058E-01
12	-2.21979E-05	-8.28236E-01	-3.44526E-03	8.29773E-03	-8.23406E-01
13	-4.31929E-06	-5.02248E-01	-5.16675E-03	3.27844E-03	-5.04140E-01
14	-5.18849E-06	-2.86214E-01	-2.38915E-03	2.35380E-03	-2.86255E-01
15	-1.12374E-06	-6.04692E-02	-1.31196E-03	-2.32507E-03	-6.41074E-02
16	-1.99189E-07	-4.90466E-02	-2.98153E-03	-4.82514E-03	-5.68534E-02
17	-1.62797E-08	-2.48566E-02	-2.06953E-03	-3.15293E-03	-3.00791E-02
18	-2.34162E-10	-1.50838E-02	-1.05390E-03	-1.76999E-03	-1.79077E-02
19	-8.20850E-11	-1.57372E-02	-1.11357E-03	-2.01865E-03	-1.88695E-02
20	-4.16697E-11	-9.86974E-03	-9.08999E-04	-1.53289E-03	-1.23116E-02
21	-2.72173E-11	-7.35905E-03	-9.14402E-04	-1.44641E-03	-9.71986E-03
22	-1.54436E-11	-4.64338E-03	-1.20370E-03	-1.30253E-03	-7.14962E-03
23	-2.15866E-08	-8.30488E-02	-3.42464E-04	3.31705E-04	-8.30595E-02
24	-2.46738E-07	-1.67903E-01	-6.01850E-04	5.65199E-04	-1.67939E-01
25	-2.32762E-07	-4.18734E-01	-1.55798E-03	7.79990E-04	-4.19512E-01
26	-7.76104E-08	-1.41617E-01	-5.48172E-04	-3.09683E-05	-1.42196E-01
27	-4.61370E-08	-1.22209E-01	-3.47209E-04	3.47719E-05	-1.22522E-01
28	-5.17937E-09	-4.58546E-02	-7.17007E-05	1.56197E-04	-4.57701E-02
29	-1.66964E-08	-5.47546E-02	-7.67983E-05	3.24057E-04	-5.45073E-02
30	-8.98762E-11	-3.04140E-02	1.17614E-05	5.14992E-04	-2.98873E-02
31	-1.33966E-09	-2.78540E-02	-1.42977E-05	7.94662E-04	-2.70737E-02
32	-6.10763E-11	-2.49976E-02	-8.15585E-05	1.23395E-03	-2.38452E-02
33	-1.30865E-12	-1.45506E-02	-2.13770E-04	9.15163E-04	-1.38492E-02
34	-2.21730E-11	-1.38374E-02	-4.53765E-04	8.33016E-04	-1.34581E-02
35	-3.84210E-12	-1.58322E-02	-1.21353E-03	-5.87725E-04	-1.76334E-02
36	-3.68359E-14	-5.90214E-03	-7.05863E-04	-9.24855E-04	-7.53285E-03
37	-3.22384E-14	-5.43174E-03	-6.92162E-04	-1.98577E-03	-8.11166E-03
38	-2.97329E-14	-1.15970E-02	-9.00080E-04	-2.17550E-03	-1.46726E-02
39	-2.71829E-16	-8.22992E-03	-8.28060E-04	-2.14529E-03	-1.12033E-02
40	0.0	-3.88606E-04	-4.85790E-04	-4.09052E-04	-1.28345E-03

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SENSITIVITY TO CROSS SECTION SET   1 IN ZONE  1

  NEUTRONS = -1.08718E-03
  GAMMAS   = -6.48227E-07
  TOTAL    = -1.08783E-03


SENSITIVITY TO CROSS SECTION SET   1 IN ZONE  2

  NEUTRONS = -6.16450E 00
  GAMMAS   = -1.19315E 00
  TOTAL    = -7.35765E 00


SENSITIVITY TO CROSS SECTION SET   1 IN ZONE  3

  NEUTRONS = -2.37568E-02
  GAMMAS   = -9.12328E-03
  TOTAL    = -3.28801E-02


SENSITIVITY TO CROSS SECTION SET   1 IN ZONE  4

  NEUTRONS =  3.16317E-02
  GAMMAS   = -1.77545E-03
  TOTAL    =  2.98562E-02


SENSITIVITY TO CROSS SECTION SET   1 IN ZONE  5
SUM OVER ZONES APPEARS AS XONE    5

  NEUTRONS = -6.15771E 00
  GAMMAS   = -1.20405E 00
  TOTAL    = -7.36176E 00
```

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ENERGY BOUNDS FOR NEUTRON GROUPS IN MEV

GRP.	ENG. 1
1	1.50000E 01
2	1.22000E 01
3	1.00000E 01
4	8.18000E 00
5	6.36000E 00
6	4.96000E 00
7	4.06000E 00
8	3.01000E 00
9	2.46000E 00
10	2.35000E 00
11	1.83000E 00
12	1.11000E 00
13	5.50000E-01
14	1.11000E-01
15	3.35000E-03
16	5.83000E-04
17	1.01000E-04
18	2.90000E-05
19	1.07000E-05
20	3.06000E-06
21	1.12000E-06
22	4.14000E-07
23	1.00000E-09

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ENERGY BOUNDS FOR GAMMA GROUPS IN MEV

GRP.	ENG. 1
1	1.00000E 01
2	8.00000E 00
3	6.50000E 00
4	5.00000E 00
5	4.00000E 00
6	3.00000E 00
7	2.50000E 00
8	2.00000E 00
9	1.66000E 00
10	1.33000E 00
11	1.00000E 00
12	8.00000E-01
13	6.00000E-01
14	4.00000E-01
15	3.00000E-01
16	2.00000E-01
17	1.00000E-01
18	5.00000E-02
19	1.00000E-04

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SENSITIVITY PER UNIT LETHARGY BY GROUP AND CROSS SECTION SET

GRP.	ZONE 1	ZONE 2	ZONE 3	ZONE 4	ZONE 5
1	-1.87979E-03	-2.12755E 00	1.13036E-03	5.93061E-03	-2.12237E 00
2	-7.67980E-04	-2.09592E 00	1.67547E-03	1.24197E-02	-2.08260E 00
3	-5.63018E-04	-2.30303E 00	2.80475E-03	2.31562E-02	-2.27763E 00
4	-3.53099E-04	-1.74328E 00	8.96445E-04	1.59336E-02	-1.72680E 00
5	-3.28941E-04	-2.01924E 00	4.19314E-04	2.31415E-02	-1.99601E 00
6	-2.44428E-04	-1.46012E 00	-3.35673E-03	5.48102E-03	-1.45824E 00
7	-1.08589E-04	-6.40427E-01	-3.16801E-03	-3.16533E-04	-6.44020E-01
8	-[illegible].48924E-04	-1.87021E 00	-1.43329E-05	1.97354E-02	-1.85074E 00
9	-3.49083E-04	-3.46473E 00	4.64405E-03	4.49067E-02	-3.41552E 00
10	-1.81558E-04	-1.94278E 00	5.49525E-04	2.13407E-02	-1.92107E 00
11	-7.25306E-05	-1.10056E 00	-2.77033E-03	1.11760E-02	-1.18222E 00
12	-3.16120E-05	-1.17949E 00	-4.90639E-03	1.18168E-02	-1.17261E 00
13	-2.69890E-06	-3.13829E-01	-3.22843E-03	2.04853E-03	-3.15011E-01
14	-1.48218E-06	-8.17621E-02	-6.82503E-04	6.72405E-04	-8.17737E-02
15	-6.42675E-07	-3.45829E-02	-7.50321E-04	-1.32973E-03	-3.66636E-02
16	-1.13623E-07	-2.79776E-02	-1.70075E-03	-2.75240E-03	-3.24309E-02
17	-1.30464E-08	-1.99200E-02	-1.65851E-03	-2.52674E-03	-2.41052E-02
18	-2.34854E-10	-1.51284E-02	-1.05701E-03	-1.77523E-03	-1.79606E-02
19	-6.55721E-11	-1.25714E-02	-8.89553E-04	-1.61256E-03	-1.50735E-02
20	-4.14589E-11	-9.81979E-03	-9.04399E-04	-1.52514E-03	-1.22493E-02
21	-2.73481E-11	-7.39441E-03	-9.18797E-06	-1.45336E-03	-9.76656E-03
22	-2.56289E-12	-7.70575E-04	-1.99756E-04	-2.16157E-04	-1.18649E-03
23	-9.67386E-08	-3.72177E-01	-1.53473E-03	1.48651E-03	-3.72224E-01
24	-1.18830E-06	-8.08626E-01	-2.89854E-03	2.72202E-03	-8.08803E-01
25	-8.87171E-07	-1.59600E 00	-5.93824E-03	2.97293E-03	-1.59897E 00
26	-3.47805E-07	-6.34645E-01	-2.45659E-03	-1.38782E-04	-6.37240E-01
27	-1.60375E-07	-4.24807E-01	-1.20692E-03	1.20069E-04	-4.25893E-01
28	-2.84079E-08	-2.51504E-01	-3.93265E-04	8.56715E-04	-2.51041E-01
29	-7.48239E-08	-2.45379E-01	-3.44166E-04	1.45224E-03	-2.44271E-01
30	-4.82350E-10	-1.63227E-01	6.31216E-05	2.76387E-03	-1.60400E-01
31	-6.04436E-09	-1.25673E-01	-6.45089E-05	3.58539E-03	-1.22152E-01
32	-2.14169E-10	-8.76559E-02	-2.85991E-04	4.32695E-03	-8.36149E-02
33	-5.86462E-12	-6.52072E-02	-9.57994E-04	4.10123E-03	-6.20640E-02
34	-7.70746E-11	-4.80997E-02	-1.57732E-03	2.89562E-03	-4.67813E-02
35	-9.47579E-12	-3.90470E-02	-2.99293E-03	-1.44951E-03	-4.34894E-02
36	-1.28044E-13	-2.05162E-02	-2.45362E-03	-3.21485E-03	-2.[illegible]1847E-02
37	-7.95095E-14	-1.34012E-02	-1.707[illegible]8E-03	-4.89750E-03	-2.00058E-02
38	-4.28955E-14	-1.67310E-02	-1.29854E-03	-3.13858E-03	-2.11681E-02
39	-3.92166E-16	-1.18733E-02	-1.19464E-03	-3.09500E-03	-1.61629E-02
40	0.0	-6.25310E-05	-7.81691E-05	-6.58211E-05	-2.06521E-04

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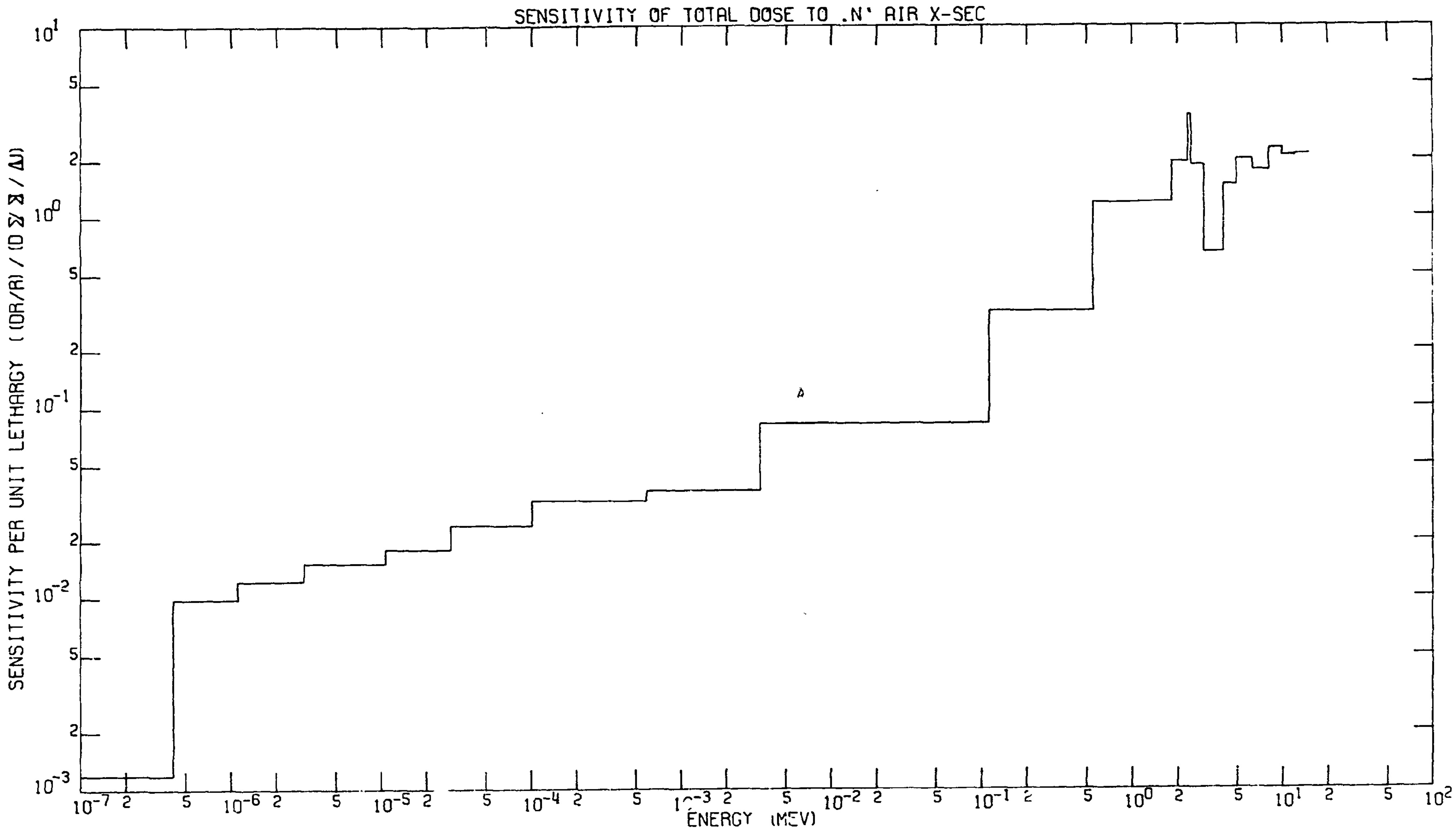

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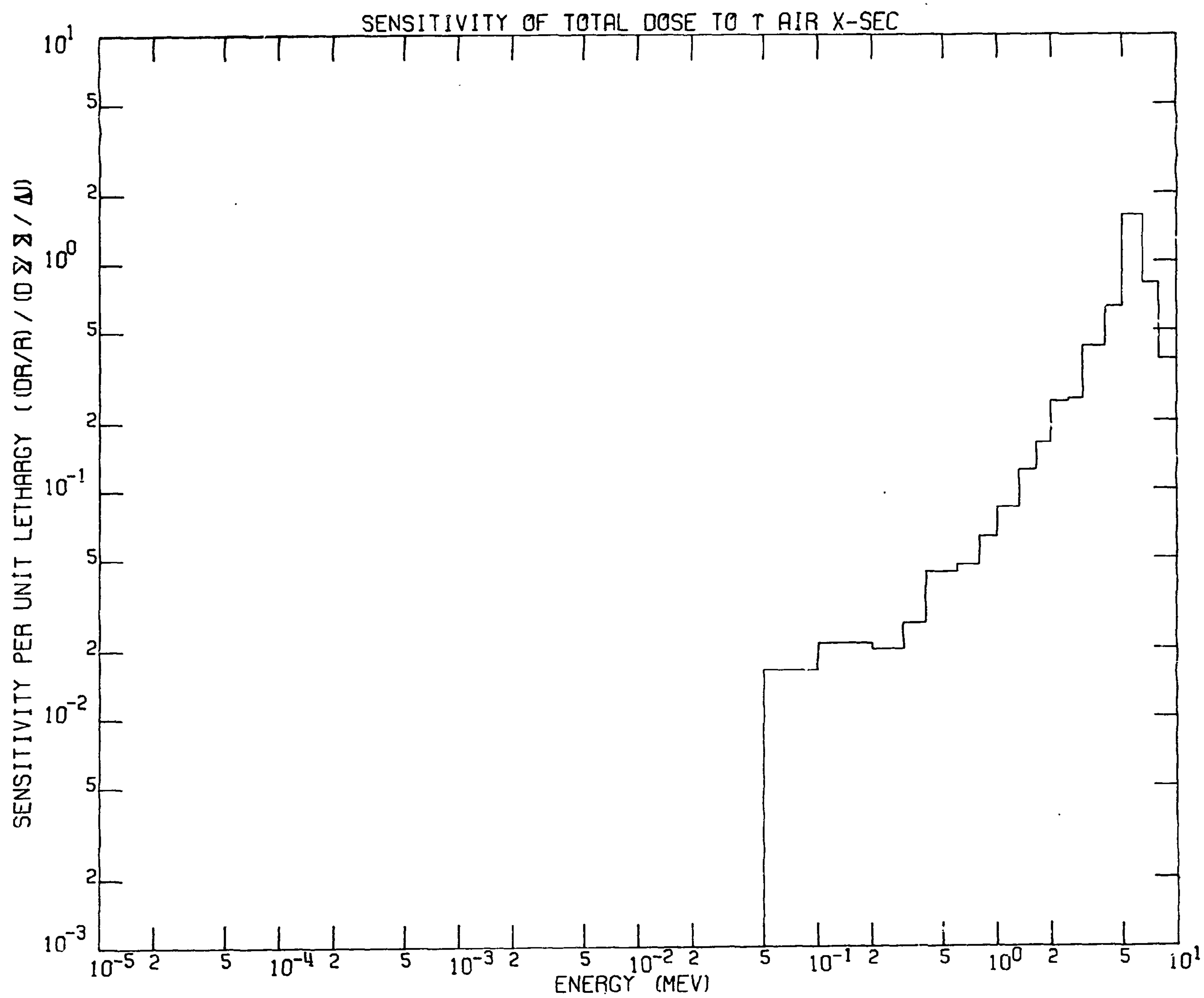

D. Discussion and Interpretation

This section discusses some of the major points of interest in analysis of the sample problem, but should not be considered a full detailed analysis.

1. P_ℓ evaluation by zone shows low P_ℓ effect in source zone 1 since the source is isotropic, a high P_ℓ effect for zone 2 where the particles are transported from the source to the detector, a lower P_ℓ effect for zone 3 where the response is calculated since the response function is isotropic and the zone volume is small, and a fairly high P_ℓ effect for zone 4, since the particles in zone 4 would have to be reflected back into zone 3 in order to contribute to the dose response. Overall, the P_ℓ effect for the entire calculation predicts that the problem could be run P_2 with only a 0.2% change in the calculated response. Going to P_1 would cause a larger change, predicted to be about -7%, and a P_0 run would result in a much larger change in the dose, predicted to be -88%. Past experience indicates that the P_2 and P_1 predictions are within the linear range, and should therefore be fairly accurate, but that the P_0 prediction is outside the linear range and is probably in error by roughly a factor of 2. In order to show the range of linearity, the forward ANISN case was recalculated for P_2, P_1, and P_0 expansions. The resulting tissue doses showed +0.2% (P_2), -6% (P_1) and -53% (P_0) changes from the P_3 calculated dose. The P_ℓ predictions by group have been successfully applied in determining a P_ℓ-by-group type calculation. For the sample problem, such a calculation might be run with neutron groups

1 to 8, 10, 11, 12 as P_2, groups 9, 13, 14 as P_1, groups 15 to 22 as P_0, and gamma group 25 as P_3, gamma groups 23, 24, 26 to 35 as P_1, and groups 36 to 40 as P_0. The net change in dose (from a straight P_3 calculation) predicted for the P_ℓ distribution just outlined is -1.03%. Recalculation of the sample problem using this P_ℓ distribution gave a net change of 1.28%.

2. The printout of sensitivity by particle type and zone shows that the calculated tissue dose is considerably more sensitive to neutron cross sections than to gamma-ray cross sections. The sensitivity for both neutrons and gamma-rays is low in the source zone 1, high in the main transport zone 2, and fairly low in both the detector zone 3 and the reflector zone 4. Note that the reflector zone 4 sensitivity is higher for neutron cross sections than zone 3, and positive, while the zone 4 sensitivity to gamma cross sections is lower than in zone 3, and negative. Although a full set of sensitivity calculations to partial reaction cross sections such as elastic, inelastic, (n,γ), etc. would be required to completely determine the reason for this behavior, some speculations can be made on the basis of the sensitivity by group printout for zone 4. In general, zone 4 or reflector sensitivity to high energy cross sections is positive, and sensitivity to lower energy cross sections is negative for both neutron and gamma cross sections. At high energy it would appear that backscatter (and gamma production for neutrons) are dominant, while non-gamma-producing absorptions and forward elastic and downscatter effects dominate at lower energies. High energy reactions in zone 4 are more

important than lower energy reactions for neutrons, but not for gammas. The sensitivity summed over zone, given as zone 5, shows that the tissue dose is fairly sensitive to the cross sections used in the calculation, (total sensitivity $\sim$7), with approximately a 5 to 1 neutron to gamma sensitivity ratio.

3. The sensitivity profiles are a measure of the relative importance of the cross section set investigated as a function of energy. Solid lines indicate a negative sensitivity and dotted lines indicate a positive sensitivity. In general, the sensitivity profiles tend to mirror the total cross section in the energy ranges which are important for a transmission problem such as the one calculated. An important minimum in the total cross section then appears as a peak in the sensitivity profile, and a resonance in the total cross section appears as a valley. The important energy ranges for a given problem are also determined by the energy distribution of the source and response functions and by the thickness of the material regions present. In the sample problem the tissue dose response function is weighted toward higher energy particles (higher energy particles give a higher dose). Since 2000m of air is fairly deep penetration and involves a relatively large number of collisions, high energy neutron cross sections are very important even though many source neutrons have lower energies. For the sample problem, 83.6% of the sensitivity to neutron cross sections (-5.15 out of -6.16) is due to cross sections for neutrons with

energies above 0.55 MeV (groups 1 through 12). The source distribution, however, only has 38.5% of the source neutrons with energies above 0.55 MeV. The sensitivity profile for both neutron and and gamma cross sections clearly shows this high energy importance. A more detailed analysis shows that the peaks for group 3 (8.18 - 10 MeV) and group 5 (4.96 - 6.36 MeV) represent energy ranges with lower nitrogen total cross sections, the valley for group 7 (3.01 - 4.06 MeV) represents a high total cross section range for both nitrogen and oxygen, and the peaks in groups 8, 9, and 10 (1.83 - 3.01 MeV) represent the energy region surrounding the oxygen minimum at 2.36 MeV, which is in group 9. The importance of minima as windows for high energy transport in deep penetration problems has long been recognized. However, in order for a minimum in the available point energy cross section data to serve as a window, and therefore to appear as a peak on the sensitivity profile, it must be adequately represented by the multigroup energy structure. The sensitivity profiles can therefore also be interpreted to give an indication of the adequacy of the energy group structure used.

APPENDICES

APPENDIX A

Derivation of the SWANLAKE Sensitivity Function

One begins with the time-independent Boltzmann equation for a non-multiplying medium expressed in the nomenclature of Section I,

$$\vec{\Omega}\cdot\nabla\Phi(\vec{r},\vec{\Omega},E) + \Sigma_T(\vec{r},E)\Phi(\vec{r},\vec{\Omega},E) \tag{A1}$$

$$- \int_{E',\vec{\Omega}'} \Sigma_S(\vec{r},\vec{\Omega}'\rightarrow\vec{\Omega},E'\rightarrow E)\ \Phi(\vec{r},\vec{\Omega}',E')dE'd\Omega' = S(\vec{r},\vec{\Omega},E)$$

then express the equation in operator notation as

$$\hat{H}\Phi = S \tag{A2}$$

and the equation for a perturbed system as

$$\hat{H}_p\Phi_p = S. \tag{A3}$$

The relationship between the perturbed and unperturbed flux is defined as

$$\Phi_p = \Phi + \Delta\Phi. \tag{A4}$$

In an analogous manner, the adjoint Boltzmann equation may be written as

$$-\vec{\Omega}\cdot\nabla\Phi^*(\vec{r},\vec{\Omega},E) + \Sigma_T\Phi^*(\vec{r},\vec{\Omega},E) \tag{A5}$$

$$- \int_{E',\vec{\Omega}'} \Sigma_S(\vec{r},\vec{\Omega}\rightarrow\vec{\Omega}',E\rightarrow E')\ \Phi^*(\vec{r},\vec{\Omega}',E')\ dE'd\Omega' = \Sigma_r(\vec{r},\vec{\Omega},E),$$

where Σ_r is the response function which is the source for the adjoint calculation. The unperturbed and perturbed Boltzmann adjoint equations may then be expressed in operator notation as

$$\hat{H}^*\Phi^* = \Sigma_r \tag{A6}$$

and

$$\hat{H}^*_p\Phi^*_p = \Sigma_r, \tag{A7}$$

and the relationship between the perturbed and unperturbed adjoint flux may be written as

$$\Phi^*_p = \Phi^* + \Delta\Phi^*. \tag{A8}$$

By integration over all phase space, the integrated response for the unperturbed problem, R, is given as

$$R = \int \Sigma_r\Phi = \int S\Phi^*, \tag{A9}$$

and R_p for the perturbed problem is

$$R_p = \int \Sigma_r\Phi_p = \int S\Phi^*_p. \tag{A10}$$

The change in R due to the perturbation is then

$$\begin{aligned} \Delta R = R_p - R &= \int \Sigma_r\Phi_p - \int \Sigma_r\Phi \\ &= \int S\Phi^*_p - \int S\Phi^*. \end{aligned} \tag{A11}$$

Applying eq. (A8),

$$\Delta R = \int S(\Phi^* + \Delta\Phi^*) - \int S\Phi^*,$$

or

$$\Delta R = \int S\Delta\Phi^*. \tag{A12}$$

From the definition given in eq. (A8), eq. (A7) becomes

$$\Sigma_r = \hat{H}^*_p(\Phi^* + \Delta\Phi^*), \tag{A13}$$

and equating (A6) and (A13) gives

$$\hat{H}^*_p(\Phi^* + \Delta\Phi^*) = \hat{H}^*\Phi^*, \quad \text{and}$$

$$\hat{H}^*_p\Delta\Phi^* = (\hat{H}^* - \hat{H}^*_p)\Phi^*. \tag{A14}$$

Now multiply through eq. (A14) by Φ_p and integrate over all phase space to get

$$\int \Phi_p \hat{H}^*_p \Delta\Phi^* = \int \Phi_p(\hat{H}^* - \hat{H}^*_p)\Phi^*. \tag{A15}$$

From the basic definition of an adjoint operator,

$$\int \Phi_p \hat{H}^*_p \Delta\Phi^* = \int \Delta\Phi^* \hat{H}_p \Phi_p, \tag{A16}$$

where boundary terms involving surface integrals are understood to have vanished under standard free-surface boundary conditions on Φ^*. Equating (A16) and (A15) gives

$$\int \Delta\Phi^* \hat{H}_p \Phi_p = \int \Phi_p(\hat{H}^* - \hat{H}^*_p)\Phi^*. \tag{A17}$$

Applying eq. (A3),

$$\int \Delta\Phi^* \hat{H}_p \Phi_p = \int \Delta\Phi^* S, \tag{A18}$$

and then from eqs. (A12), (A17), and (A18),

$$\Delta R = \int \Phi_p (\hat{H}^* - H_p^*)\Phi^*. \tag{A19}$$

Now define an operator $\hat{T}_\Sigma$ by the equation

$$\hat{T}_\Sigma \Phi^* = (\hat{H}^* - \hat{H}_p^*)\Phi^*, \tag{A20}$$

and require that

$$\hat{T}_\Sigma \Phi^* = \Delta C \Bigg[- \Sigma_T(\vec{r},E)\Phi^*(\vec{r},\vec{\Omega},E) + \int_{E',\vec{\Omega}'} \Sigma_S(\vec{r},\vec{\Omega}\to\vec{\Omega}',E\to E')\ \Phi^*(\vec{r},\vec{\Omega}',E')\ dE'd\Omega' \Bigg], \tag{A21}$$

where C is a constant ratio for all cross sections,

$$C = \frac{\Sigma_T^p(\vec{r},E)}{\Sigma_T(\vec{r},E)} = \frac{\Sigma_S^p(\vec{r},\vec{\Omega}\to\vec{\Omega}',E\to E')}{\Sigma_S(\vec{r},\vec{\Omega}\to\vec{\Omega}',E\to E')} \tag{A22}$$

for all E, $\vec{r}$, E', $\vec{\Omega}'$, and $\vec{\Omega}$.

Then

$$\Delta C = \frac{\Sigma_T^p(\vec{r},E) - \Sigma_T(\vec{r},E)}{\Sigma_T(\vec{r},E)} = \frac{\Delta\Sigma_T(\vec{r},E)}{\Sigma_T(\vec{r},E)} , \tag{A23}$$

$$= \frac{\Sigma_S^p(\vec{r},\vec{\Omega}\to\vec{\Omega}',E\to E') - \Sigma_S(r,\vec{\Omega}\to\vec{\Omega}',E\to E')}{\Sigma_S(r,\vec{\Omega}\to\vec{\Omega}',E\to E')} = \frac{\Delta\Sigma_S(\vec{r},\vec{\Omega}\to\vec{\Omega}',E\to E')}{\Sigma_S(\vec{r},\vec{\Omega}\to\vec{\Omega}',E\to E')} ,$$

so that ΔC is also a constant over E, $\vec{r}$, E', $\vec{\Omega}'$ and $\vec{\Omega}$ for all cross sections. This will be denoted in an abbreviated form as $\Delta C = \frac{\Delta\Sigma}{\Sigma}$. Now take eqs. (A19) and (A20) to give

$$\Delta R = \int \Phi_p \hat{T}_\Sigma \Phi^* . \tag{A24}$$

Dividing through both sides of eq. (A24) by R as defined in eq. (A9) and by ΔC gives

$$\frac{\Delta R/R}{\Delta C} = \frac{\int \Phi_p \hat{T}'_\Sigma \Phi^*}{\int \Sigma_r \Phi} , \tag{A25}$$

where $\hat{T}'_\Sigma = \frac{\hat{T}_\Sigma}{\Delta C}$.

The derivation of the sensitivity function can now proceed in either of two ways.

A → Take the limit of eq. (A25) as $\Delta C \to 0$, giving

$$\frac{\partial R/R}{\partial C} = \frac{\partial R/R}{\partial \Sigma/\Sigma} = \frac{\int \Phi T'_\Sigma \Phi^*}{\int \Sigma_r \Phi} \tag{A26}$$

B → Make the standard linear perturbation assumption that $\Phi_p \simeq \Phi$ and obtain

$$\frac{\Delta R/R}{\Delta C} = \frac{\Delta R/R}{\Delta\Sigma/\Sigma} = \frac{\int \Phi T_{\Sigma}' \Phi^*}{\int \Sigma_r \Phi} \quad . \tag{A27}$$

The right hand side of eqs. (A26) and (A27) is now the matrix-and-operator notation form for the basic sensitivity definition given in Section I, eq. (1). Equation (A26) has meaning without specifying a value for C, and is used analytically to determine the relative sensitivity of the response function, R, to the cross sections used in the calculation. Equation (A27) requires a specific value for C, and is used predictively to estimate the change in the response function caused by a change in the cross section corresponding to ΔC.

This differentiation into two aspects of sensitivity is intended to emphasize the fact that no specific value is chosen for ΔC in the analytical application of the sensitivity function, while specifying ΔC results in a predicted change in R which is only valid within the range of linear perturbations.

It should be noted that the sensitivity function given in eqs. (A26) and (A27) is defined over a specific domain of E and $\vec{r}$ by specifying the domain of $\hat{T}_{\Sigma}\Phi^* = (\hat{H}^* - \hat{H}_p^*)\Phi^*$. This is equivalent to setting $\Delta C = 0$ outside of the chosen domain. Sensitivities may then be determined for a given type of cross section (collision, elastic, inelastic, etc.) as a function of energy in a given spatial zone.

APPENDIX B

Machine Requirements for Sample Problems

This appendix is included to give the user some examples of machine requirements (time and core) for SWANLAKE cases. All times and core requirements given are for the IBM 360/91 system at Oak Ridge National Laboratory. Table I gives the problem specifications for four different sensitivity problems. Details on the sensitivity analyses for these problems are available in the listed references. Table II indicates running time, total core, and blank common requirements for sensitivity calculations relating to problems A, B, C, and D. Table II also includes the number of cross section sets to be analyzed and an indication of whether the $\Phi^{*}\Phi$ matrix was calculated (ITAPE = 1) or read from a previous calculation (ITAPE = 2).

Table I. Sample Problem Specifications

Problem	Source	Medium	Response	Energy Groups	Spatial Intervals	Spatial Zones	P_ℓ	S_n	Geometry
A	Unclassified Thermonuclear	2000m air	neutron + gamma tissue dose	40(22n,18γ)	169	4	P_3	S_{40}	spherical
B[17]	Unclassified Thermonuclear	2000m air	neutron + gamma tissue dose	134(101n,33γ)	179	1	P_3	S_{16}	spherical
C[18]	FTR radial shield leakage spectrum	15'Na + 3'Fe	neutron tissue dose	50	302	2	P_3	S_{16}	slab
D[19]	14 MeV neutrons	a proposed controlled thermonuclear reactor blanket	Tritium breeding from Li^6 and Li^7	100	62	8	P_3	S_{12}	cylindrical

Table II. Sample Problem Machine Requirements

Problem	Σ Sets	ITAPE	Total Core (bytes)	Blank Common (bytes)	Running Time (minutes)
A	1	1	290K	172K	1.8
B	2	1	848K	720K	2.2
B	2	2	844K	720K	1.0
C	2	1	384K	240K	1.5
D	2	1	536K	395K	3.6
D	2	2	504K	392K	1.0

APPENDIX C

Source Units and Activities

In order for the forward and adjoint angular fluxes produced by ANISN to be compatible with SWANLAKE, the forward distributed source units should be $\left(\frac{\text{neutrons}}{\text{cm}^3 \text{ x sec}}\right)$, and the corresponding adjoint source units should be $\left(\frac{\text{response}}{\text{neutron x cm}}\right)$, i.e., the units of a macroscopic cross section. Response functions such as dose are frequently given in the literature in units of $\left(\frac{\text{response}}{\text{neutron/cm}^2}\right)$, and must be divided by the volume for an interval before being input as an adjoint source for that interval. The forward source, in the form first printed out in the forward output, should be input as the adjoint response function. This ensures that any normalization of the forward source will be included. The forward response function and the adjoint source should be input in exactly the same form. In this discussion it is assumed that the adjoint source will not be normalized.

If the preceding input criteria are followed, the activity (response) calculated by ANISN for interval J will be

$$R_J^{for}\left(\frac{\text{response}}{\text{cm}^3 \text{ x sec}}\right) = \sum_{I=1}^{IGM} \Phi_{I,J}\left(\frac{\text{neutrons}}{\text{cm}^2 \text{ x sec}}\right) D_{I,J}\left(\frac{\text{response}}{\text{neutron x cm}}\right) \tag{C1}$$

in the forward case, and

$$R_J^{adj}\left(\frac{\text{response}}{\text{cm}^3 \text{ x sec}}\right) = \sum_{I=1}^{IGM} \Phi^*_{I,J}\left(\frac{\text{response}}{\text{neutron}}\right) S_{I,J}\left(\frac{\text{neutrons}}{\text{cm}^3 \text{ x sec}}\right) \tag{C2}$$

for the adjoint case, where

$D_{I,J}$ is the adjoint source and the forward response function,

and $S_{I,J}$ is the forward source in the form input as the adjoint response function.

To compare the total responses calculated by the forward and adjoint ANISN cases, the forward response by interval must be integrated over the domain of interest for the forward response function, and the adjoint response must be integrated over the domain of the forward source. The phrase "domain of interest for the forward response function" is included because the forward response is frequently calculated for more intervals than are relevant to the particular problem under investigation. For example, in the sample problem the tissue dose is calculated in each interval in the forward case, but the total response considered is the tissue dose at 2000m (spatial interval 131), and so the forward response function is input as the adjoint source only in interval 131. In general, the total forward and adjoint responses to be compared may be expressed as

$$R^{for}\left(\frac{\text{response}}{\text{sec}}\right) = \sum_{J}^{\substack{\text{Domain of} \\ \text{Interest for D}}} R_J^{for} \ \text{VOL}_J \ , \tag{C3}$$

and

$$R^{adj}\left(\frac{\text{response}}{\text{sec}}\right) = \sum_{J}^{\text{Domain S}} R_J^{adj} \ \text{VOL}_J \ . \tag{C4}$$

Since the activity by zone (response by zone) computed by ANISN is the integral of the interval responses in the zone, it is helpful to specify the spatial region of interest for the forward response function and the spatial region containing the forward source as separate zones, where possible.

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