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BRT-I: BATTELLE-REVISED-THERMOS

C. L. Bennett
W. L. Purcell

June 1970

AEC RESEARCH & DEVELOPMENT REPORT

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BATTELLE MEMORIAL INSTITUTE
PACIFIC NORTHWEST LABORATORIES
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Reactor Physics Department
Physics and Engineering Division

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COMPUTER CODE ABSTRACT

1. Name: BRT-I (BATTELLE-REVISED-THERMOS)
2. Computer: BRT-I is designed to operate on the UNIVAC 1108 computer system.
3. Nature of Physical Problem Solved: The code computes the space dependent thermal neutron density, flux and current spectra over the energy range 0 to 0.683 eV in either slab or cylindrical geometry.
4. Method of Solution: The neutron density is computed from the collision probability form of the integral transport-theory matrix equation using either a combination of power iteration, overrelaxation and extrapolation or straight power iteration. The neutron currents are computed from either the gradient of the scaler flux or the uncollided flux matrix. The flux and current spectra is used to weight point thermal cross sections over an arbitrary thermal energy range for use in multigroup transport or diffusion theory codes.
5. Restrictions on the Complexity of the Problem: Number of space points ≤30, number of isotopes ≤30, number of speed points ≤30, number of material mixtures <8, slab or cylindrical geometry.
6. Typical Running Time: With the random access library: 1 minute with a reflecting boundary condition and 30 seconds with a white boundary condition. Succeeding cases using the same cross sections take about 15 seconds each.

7. Unusual Features of the Code: White albedo boundary condition, current calculation, transverse buckling, linear anisotropic scattering correction, and smeared cell punched card output which can be used as region input for a succeeding case, are several of the options available to the user. A random access library data element can be stored on drum or disk memory, if available, resulting in a considerable decrease in running time.

8. Related and Auxiliary Programs: RLITHE, updates and/or prints the BRT data tape or random access data element.

9. Status: BRT-I is in production use on the UNIVAC-1108 computer at Pacific Northwest Laboratory, Richland, Washington.

10. References:

- H. C. Honeck, THERMOS. A Thermalization Transport Theory Code for Reactor Lattice Calculations, BNL-5826. Brookhaven National Laboratory, Upton, New York, September 1961.
- D. R. Skeen and L. J. Page. THERMOS/BATTELLE: The Battelle Version of the Thermos Code, BNWL-516, June 1967, Pacific Northwest Laboratory, Richland, Washington.
- J. E. Suich and H. C. Honeck. The HAMMER System, DP-1064, Savannah River Laboratory, Aiken, South Carolina, January 1967.
- B. J. Toppel and I. Baksys. The Argonne-Revised THERMOS Code, ANL-7023, Argonne National Laboratory, Lemont, Illinois, March 1965.

Machine Requirements: 64K memory, normal input, output, program, and punch units, 1 unit for library, 3 scratch units or their equivalent on drum.

Programming Language Used: FORTRAN-IV.

13. Operating System: UNIVAC-1108 computer with FORTRAN-V compiler and CSCX operating system.

14. User Information: The code and report may be obtained either through the Argonne Code Center at Argonne National Laboratory or from Pacific Northwest Laboratory in Richland, Washington.

15. Material Available: Magnetic Tape transmittal.
BRT-1 Source deck (approximately 2600 cards)
RLITHE Source deck (less than 500 cards)
Library deck (8000 cards)
Sample problem (23 cards)

16. Acknowledgement: This work is based on work performed under U.S. Atomic Energy Commission Contract AT(45-1)-1830.

C. L. Bennett
W. L. Purcell
Reactor Physics Department
Battelle-Northwest
P.O. Box 999
Richland, Washington

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BRT-I: BATTELLE-REVISED-THERMOS

C. L. Bennett and W. L. Purcell

INTRODUCTION

Many revisions have been made to the THERMOS[1] code by various authors. A previous report[2] described a code, called THERMOS/BATTELLE, which had incorporated into it certain revisions[3,4] made to THERMOS prior to 1967. Recently further modifications have been made to THERMOS/BATTELLE which have now been sufficiently evaluated for general release. For the sake of completeness and clarity a new code, called Battelle-Revised, THERMOS (BRT-I), was generated which contains all revisions made to date. These revisions and a complete set of revised input instructions are described in this report. The new code is available to users through the Argonne Code Center.

INCLUSIONS AND REVISIONS INTRODUCED

Library Tape

An improved library tape has been included which contains the first moment scatter matrices for a number of elements and contains the free atom scattering cross section for all elements. Any one BRT-I case will allow up to 30 elements.

Transport Kernel Calculation in Voids[4]

The transport kernel modifications for the treatment of void regions has been added to the standard treatment.

Transport Kernel--Cosine Current[3]

The cosine current calculation of the transport kernel has been added and modified to allow for the input of a right hand albedo.

Cylindrical and Slab Geometry

The transport kernel calculations in both cylindrical and slab geometry for up to 30 space points have been placed at the user's option.

Cell Smear

A smear option has been added which gives punched card output of a smeared cell which can be used for region input to a later BRT-I case.

The cell smeared $\bar{\Sigma}_a(v)$, $\bar{\Sigma}_f(v)$, $\bar{\Sigma}_{s_0}(v)$, $\bar{\Sigma}_{s_1}(v)$, are obtained from

$$\bar{\Sigma}(v) = \frac{\int_{cell} \Sigma(r,v)\phi(r,v)dV}{\int_{cell} \phi(r,v)dV}, \qquad (1)$$

$\bar{\nu}(v)$ from

$$\bar{\nu}(v) = \frac{\int_{cell} \nu(r,v)\Sigma_f(r,v)\phi(r,v)dV}{\int_{cell} \Sigma_f(r,v)\phi(r,v)dV} \qquad (2)$$

and the scattering kernel from

$$\bar{P}_o(v\rightarrow v') = \frac{\int_{cell} P_o(v\rightarrow v',r)\phi(r,v)dV}{\int_{cell} \phi(r,v)dV}$$

The anisotropic corrected scattering kernel is not used in obtaining the cell smeared kernel in Equation (3), since this correction would normally be made in the succeeding case in which the smeared cell data is used. Note also that since Equation (3) is applied at each speed, it is immaterial whether flux or neutron density weighting is used. The cell smeared source is obtained by simply volume weighting the unnormalized source distribution,

$$\bar{s}(v) = \int_{cell} s(r,v)\,dV \Big/ \int_{cell} dV. \qquad (4)$$

The unnormalized rather than the normalized source is used in Equation (4) in order to preserve the relative magnitude of the slowing down density in the smeared cell with respect to other smeared cells or other dissimilar moderating materials which may be present in succeeding cases. The user must first have, of course, provided the properly normalized spatial source distribution in the original cell case.

If the slowing down density $q(r,v^*)$ is known for the original cell, then

$$s_d(r) = q(r,v^*) \Big/ \sum_i \xi_i \Sigma_{s_i}(r) \qquad (5)$$

provides the correct normalization, where i refers to isotope i and Σ_s is the high energy scattering cross section used by either BRT-I or RLITHE to generate the source.

The smeared cell set obtained, as outlined above for a nonleakage case, will reproduce the cell average flux spectrum of the original case exactly when used in a succeeding infinite medium case with a flat spatial source distribution and the same anisotropic scattering option. Such is not the case however, if the original cell has leakage, since the non-leakage probability (dependent on both r and v) has not been included in the integral of the numerators of Equations (3) and (4) above.

Anisotropic Scattering Correction

An approximate method of correcting for linear anisotropic scattering[4] is incorporated in Battelle-Revised-THERMOS. The decision to apply this correction to all materials used in the cell is left up to the user. The option is controlled by the input parameter NANI on Card 3.

The anisotropic correction to the scattering kernel is applied only to the diagonal terms, i.e.,

$$P(v\to v') = P_o(v\to v') - \delta(v-v')\int_o^{v^*} dv' P_1(v\to v') \qquad (6)$$

or

$$P(v\to v') = P_o(v\to v') - \delta(v-v') v\, \sigma_{s1}(v).$$

For materials without a first moment scattering kernel

$$\sigma_{s1}(v) \simeq \frac{2}{3A}\sigma_{so}(v). \qquad (7)$$

is assumed. In order to maintain neutron balance, the anisotropic correction must also be applied to the total cross section, i.e.,

$$\sigma_t'(v) \equiv \sigma_t(v) + \frac{1}{v}\int_o^{v^*} dv' P(v\to v') \qquad (8)$$

$$= \sigma_a(v) + \sigma_{so}(v) - \sigma_{s1}(v) \equiv \sigma_{tr}(v).$$

Relaxation Correction

The relaxation routine internal to the flux iteration calculation has been modified to switch the calculation to a standard power iteration in case of numeric difficulties (often encountered when using the Anisotropy Correction).

Fission Cross Section Averaging

Fission cross section averaging both microscopically per isotope and macroscopically for the cell has been included in the editing routines.

Mixture Expansion

The code is now equipped to handle up to eight material mixtures.

Transverse Buckling

Battelle-Revised-THERMOS computes a correction factor of the DB^2 form for finite transverse dimensions. The use of the option is controlled by the input parameter NBUCK (Card 3), as shown in the following table.

THERMOS Geometry	NBUCK	B^2
Slab or Cylinder	0	0
Slab or Cylinder	1	$(\pi/z')^2$
Slab	2	$(\pi/z')^2 + (\pi/y')^2$
Slab	3	$(2.405/R')^2$

If NBUCK $\neq$ 0, the extrapolation factor (BF) and dimension(s) (DZ, DY) are read from Card 4. The extrapolation factor is used to add an extrapolated distance $d = (BF)(0.710446)(\lambda_{tr})$ to the input transverse dimensions, i.e., $Z' \equiv DZ + d$, $Y' \equiv DY + d$, $R' \equiv DZ + d$. The buckling correction factor is applied to $\Sigma_a(r,v)$; i.e.,

$$\Sigma_a'(\underline{r},v) = \Sigma_a(\underline{r},v) + D(\underline{r},v)B^2 \qquad (9)$$

where

$$D(\underline{r},v) \equiv 1/3\ \Sigma_{tr}(\underline{r},v).$$

Random Access Data File[5]

The UNIVAC 1108 computer has, as part of the hardware, directly addressable drum storage with relatively short access times. The software provides the capability of creating data files in binary form which can reside on these drums. Thus, one obvious method of reducing the time required for a calculation is to utilize these drums as the peripherial storage device on which the data library resides during execution. The time required for a calculation can be reduced still further by utilizing the direct addressing capability of the drum and accessing only that information required for the computation.

To create the directly addressable drum file it is necessary to identify each unique data block and to determine the relative address of this data block with respect to the starting address of the drum file. This information is then made a part of the data file so that it is available when the data file is used.

To use the data file, it is necessary to attach a name to the file when it is created. This name is used to identify the file to the program via the control card,

∇ DAT name/version,n

where the name/version is the name attached to the file when created, and n is an integer from 0 to 9 indicating which of the 10 possible data files is to be initialized. However, the value of n is not arbitrary; it must be the same as that used in the program to reference the data file. Hence, the value of n is unique and must be obtained from the program input description before attempting to use the data file.

Multiple Edits

This option is used to get multiple group structure edits with a maximum of five broad groups over the energy range.

The option may be invoked as many times as desired for a given run, thus allowing many group outputs with minimum cost. This option is controlled by the variable IBY on input Card 2 as described in the input instructions.

Isotropic Albedo Boundary Condition

The BRT-I code can utilize a generalized boundary condition in lieu of the present restriction to only vacuum or reflecting boundaries. This modification is described in more detail in a later section.

Current Calculations

Neutron current calculation routines have been incorporated into BRT-I. The neutron current information is used to weight the transport and first moment scatter cross sections. Two options are available; a diffusion theory approximation, and an improved technique which utilizes information contained in the transport matrix, $T(r,r',v)$. This modification is described in more detail in a later section.

ISOTROPIC ALBEDO BOUNDARY CONDITION

The THERMOS code (at present cylindrical geometry version only) was modified to allow a generalized boundary condition in lieu of the present restriction to only vacuum or reflecting boundaries. The modification presupposes the knowledge of the velocity dependent outer albedo and in addition contains an isotropic boundary return assumption even in the case of $A(v) = 1$ for all v (A is the albedo). Several authors (6-8) have shown that the mirror reflection from the equivalent cylindrical boundary produces significant error in the calculated thermal disadvantage factors. Honeck[9] showed that using an isotropic boundary return instead of mirror reflection from the equivalent boundary does result in improved calculated lattice parameters, the most notable improvement being to the thermal disadvantage factor. His method of obtaining an isotropic boundary condition was to add an extra region, either containing a heavy scatterer or homogenized cell mixture, outside the cylindrical cell. The method outlined herein can be used instead of adding an extra region.

The modification included in BRT-I is accomplished as follows:

The regular transport kernel T_{nki}^{vac} is replaced in the calculation by T^*_{nki} where the subscripts n and k refer to geometric regions, the subscript i (which will be dropped hereafter for convenience) refers to a speed group, T^{vac} refers to the kernel as normally calculated by BRT (or the original THERMOS) under the vacuum boundary condition, and

$$T^*_{nk} = T_{nk}^{vac} + \frac{\dfrac{4AV_k}{s_b}\left(1 - \sum_{m=1}^{N} \Sigma_m T_{nm}^{vac}\right)\left(1 - \sum_{m=1}^{N} \Sigma_m T_{kn}^{vac}\right)}{1 - A\left[1 - \dfrac{4}{s_b}\sum_{j=1}^{N} V_j \Sigma_j \left(1 - \sum_{l=1}^{N} \Sigma_l T_{jl}^{vac}\right)\right]} \qquad (10)$$

where V and Σ are the volume per unit length and total cross section, respectively, and s_b is the surface area per unit length of the outer boundary.

THEORY OF MODIFICATION

A generalized isotropic boundary condition is formulated for symmetric cylindrical geometry, integral transport theory solutions in terms of an assumed known outer albedo. The inclusion of such an albedo boundary condition requires only a simple modification of the ordinary first flight collision probabilities.[10,11] This modification is derived by simply extending Leslie et al.[12] "overall" collision probability arguments to allow a known boundary escape.

Consider an infinitely long cylindrical system, bounded radially at outer radius R_b, and composed of N annular regions. Within this system consider a number of neutrons starting from
* an isotropic, spatially uniform distribution in some annular Region j. The fraction P_{jk} will collide in annular Region k, $\sum_{\text{all } m \neq k} P_{jm}$ will collide in regions other than Region k, and $P_{jb} = 1 - \sum_{m=1}^{N} P_{jm}$ will reach the boundary without previous collision. Of the first flight neutrons reaching the boundary, the Fraction 1-A, where A is the albedo, will escape the system and the Fraction A are assumed to be isotropically returned. Of these returned neutrons, the Fraction P_{bk} will collide in Region k and $P_{bb} = 1 - \sum_{m=1}^{N} P_{bm}$ will reach the boundary again.

The Fraction A of these neutrons reaching the boundary will bounce off it isotropically. A fraction P_{bk} of the remaining neutrons will collide in Region k and so on.

Summing all the appropriate collision probabilities gives the "overall" or total probability (P^*_{jk}) of collision in Region k for a neutron born uniformly in Region j; i.e.,

$$P^*_{jk} = P_{jk} + P_{jb}AP_{bk} + P_{jb}AP_{bb}AP_{bk} + P_{jb}(AP_{bb})^2\, AP_{bk} + \ldots,$$

$$= P_{jk} + \frac{AP_{jb}\ P_{bk}}{1 - AP_{bb}} \qquad (11)$$

Due to the isotropic boundary return assumption P_{bk} can be found from the standard reciprocal relationship[13,14]

$$P_{bk} = \frac{4V_k \Sigma_k}{s_b} P_{kb}, \qquad (12)$$

where V_k, s_b and Σ_k are the volume per unit length, boundary surface area per unit length, and total cross section of annular Region k, respectively. The ordinary collision probabilities needed to complete the P* definitions are presently calculated by both the ray tracing,[1] and cosine current[3] methods.

It can be shown that there is neutron conservation from,

$$P^*_{jo} + \sum_{k=1} P^*_{jk} = 1, \qquad (13)$$

where the total escape probability P^*_{jo} can be derived in a manner similar to that used to obtain the total collision probabilities P^*_{jk}.

The first flight collision probability P_{jki} can be related to the uncollided flux T_{kji} by the following expression

$$P(V_j \rightarrow V_k, v_i) = \frac{V_j \; T(V_k \leftarrow V_j, v_i)}{V_k \; \Sigma(V_k, v_i)} \qquad (14)$$

or

$$P_{jki} = \frac{V_j T_{kji}}{V_k \Sigma_{ki}} .$$

NEUTRON CURRENT CALCULATION

The calculation of the diffusion coefficient in the THERMOS/BATTELLE code[2] is based on the neutron current. This version utilized the diffusion theory approximation in computing the current (i.e., gradient of the flux). This approximation can be shown in equation form as

$$\phi_1(v,r) = \frac{\nabla\phi_o(v,r)}{\Sigma_{TR}(v,r)} \quad (15)$$

where $\nabla\phi(v,r)$ is calculated by a least squares fit of the log of three neighboring flux points.

An improved approximation[15] which uses information contained in the transport matrix has been inco'rporated into the Battelle-Revised-THERMOS code. This method is described below.

In the THERMOS code, the basic neutron balance equation is written as[1]

$$N(\underline{r},v) = \int H'(\underline{r}',v)T(\underline{r},\underline{r}',v)d\underline{r}' \quad , \quad (16)$$

where $N(\underline{r},v)dv$ is the number density of neutrons at position $\underline{r}$ having speed v in dv, and $H'(\underline{r},v) = \frac{1}{v} H(\underline{r},v)$ where $H(\underline{r},v)\, dv$ is the birth rate density of neutrons at position $\underline{r}$ with speeds in dv. The kernel $T(\underline{r},\underline{r}',v)$ represents the flux of uncollided neutrons at $\underline{r}$ produced by a unit source of neutrons of speed v located at $\underline{r}'$.

Consider a one-dimensional system (slab, cylinder, or sphere) and denote the spatial coordinate by r. Consider a surface $r = r_o$, which is either a plane or the surface of a cylinder or sphere. The net neutron current crossing the surface $r = r_o$ can be determined as follows.

First assume that no neutrons leak from the system. Suppose that a unit source of neutrons of speed v is located at a point $\underline{r}'$, where $r' > r_o$. The uncollided flux at any other point $\underline{r}''$ is then $T(\underline{r}'',\underline{r}',v)$. Thus the number of first collisions which occur per unit time in the region $r'' < r_o$ is given by

$$N1 = \int_{r' < r_o} T(\underline{r}'',\underline{r}',v)\ \Sigma_t\ (\underline{r}'',v)d\underline{r}'' \quad . \tag{17}$$

Since one neutron is produced per unit time, this expression also represents the fraction of neutrons born at $\underline{r}'$ which flow across the surface $r = r_o$. Since $vH'(\underline{r}',v)$ neutrons are born at $\underline{r}'$ per unit time, the total number of neutrons per unit time which flow across r_o in the direction of decreasing r is given by

$$S(r_o)J_-(r_o,v) = \int_{r'>r_o} d\underline{r}' \int_{r''<r_o} d\underline{r}''\ vH'\ (\underline{r}',v)T(\underline{r}'',\underline{r}',v)\ \Sigma_t\ (\underline{r}'',v) \tag{18}$$

where $S(r_o)$ is the area of the surface $r = r_o$. Similarly, it follows that

$$S(r_o)J_+(r_o,v) = \int_{r'<r_o} d\underline{r}' \int_{r''>r_o} d\underline{r}''\ vH'(\underline{r}',v)T(\underline{r}'',\underline{r}',v)\ \Sigma_t(\underline{r}',v). \tag{19}$$

The net neutron current flowing across the surface is then

$$J(r_o,v) = J_+(r_o,v) - J_-(r_o,v). \tag{20}$$

If one considers a system with leakage out one surface, say $r = r_s$, the above expressions must be modified slightly. For a unit source of neutrons at $\underline{r}'$, the rate of first collisions in the entire system is

$$Q(\underline{r}',v) = \int_{\text{all } r''} T(\underline{r}'',\underline{r}',v)\ \ \Sigma_t(\underline{r}'',v)dr''. \tag{21}$$

Since one neutron is produced per unit time, $Q(\underline{r}',v)$ is also the first-flight nonleakage probability for neutrons born at $\underline{r}'$. The corresponding leakage probability is defined by

$$L(\underline{r}',v) = 1 - Q(\underline{r}',v). \tag{22}$$

With leakage occurring through the surface $r = r_s$, the expression for $J_-(r_o,v)$, Equation (18), remains unchanged except that the $\underline{r}'$ integration now runs over $r_o \le r' \le r_s$. The expression for $J_+(r_o,v)$ must be altered to account for those neutrons which cross the surface $r = r_o$ and continue on to leave the system through the surface $r = r_s$. Clearly, the appropriate expression is

$$S(r_o)J_+(r_o,v) = \int_{r'<r_o} d\underline{r}'\, H(\underline{r}',v) \Bigg[L(\underline{r}',v) + \int_{r_o<r''<r_s} d\underline{r}''\, vH'(\underline{r}',v)T(\underline{r}'',\underline{r}',v)\, \Sigma_t(\underline{r}'',v) \Bigg]. \tag{23}$$

The modified current equations are then given by

$$J_-(r_o,v) = \int_{r'\ge r_o} d\underline{r}'\, H(\underline{r}',v) \Bigg[L_-(\underline{r}',v) + \int_{r''\le r_o} d\underline{r}''T(\underline{r}'',\underline{r}',v)\, \Sigma_t(\underline{r}'',v) \Bigg] \tag{24}$$

and

$$J_+(r_o,v) = \int_{r'\le r_o} d\underline{r}'\, H(\underline{r}',v) \Bigg[L_+(\underline{r}',v) + \int_{r''\ge r_o} d\underline{r}''\, T(\underline{r}'',\underline{r}',v)\, \Sigma_t(\underline{r}'',v) \Bigg]. \tag{25}$$

One other case remains, namely that of the double vacuum boundary slab. For this special case, it is necessary to have additional information about which side of the slab the neutrons leak out. This information can be made available at the time of the $T(\underline{r},\underline{r}',v)$ matrix calculation. The left and right hand leakage is then given approximately by

$$L_{-}(\underline{r}',v) \cong L(\underline{r}',v) \left[\frac{T(\underline{r}-,\underline{r}',v)}{T(\underline{r}-,\underline{r}',v) + T(\underline{r}+,\underline{r}',v)}\right] \quad (26)$$

and

$$L_{+}(\underline{r}',v) \cong L(\underline{r}',v) \left[\frac{T(\underline{r}+,\underline{r}',v)}{T(\underline{r}-,\underline{r}',v) + T(\underline{r}+,\underline{r}',v)}\right] \quad (27)$$

where $T(\underline{r}-,\underline{r}',v)$ and $T(\underline{r}+,\underline{r}',v)$ are defined as the flux transport from $\underline{r}'$ to the left hand and right hand boundary $\underline{r}-$ and $\underline{r}+$, respectively.

EFFECT OF MODIFICATIONS

The effect of adding a transverse buckling or using a white boundary condition was tested on a 0.75 in. square pitch - 2.36 wt% enriched UO_2 cell. In all cases the anisotropic scattering correction was used. Case 1 (the base case) had a reflecting boundary condition. In Case 2 an effective axial height of 105.31 cm was used. In Case 3 the white boundary condition was used. The effect on the various lattice parameters can be seen by comparing the results in Table I.

As expected, the spectral change caused by the relatively small axial buckling is almost negligible. However, for this tight of a pitched lattice, the effect of not using the more proper white boundary condition could cause about a 0.3% underprediction in the cell k_∞.

TABLE I. Effect of Modification

Lattice Parameter	Base Case Case 1	Buckling Case Case 2	White Boundary Case Case 3
$\overline{1/v}$	7.4765-1	7.4730-1	7.4588-1
$\overline{\Sigma_a}$	7.6232-2	7.6169-2	7.6830-2
$\overline{\Sigma_s}$	2.0380+0	2.0378+0	2.0258+0
$\overline{\nu\Sigma_f}$	1.1273-1	1.1262-1	1.1392-1
$\overline{\Sigma_f}$	4.6390-2	4.6346-2	4.6880-2
$\overline{\Sigma_{s1}}$	3.8798-1	3.8859-1	3.8877-1
$\overline{D}$	1.9083-1	1.9091-1	1.9187-1
ηf	1.47878	1.47855	1.48275
f	0.83764	0.83757	0.84000
η	1.76541	1.76529	1.76518
ϕ_{mod}/ϕ_{fuel}	1.20798	1.20872	1.18350

The effect of the improved current calculation on the diffusion coefficient has been determined for some plutonium fueled H_2O moderated reactor systems. Calculated diffusion coefficients are compared in Table II. Included are results obtained using the HAMMER code.[3] The first column is from HAMMER, the second shows calculations from the foregoing theory in BRT-I, and the third column shows values calculated, using the gradient calculation which was reported in the THERMOS/BATTELLE document.[2]

TABLE II. Calculated Diffusion Coefficients

Case	Diffusion Coefficients		
	HAMMER	T Calc.	$-D\nabla\cdot\phi$
Slab Geometry			
MTR Phoenix Cell(16)	0.267	0.250	0.671
Cylindrical Geometry			
EBWR Criticals 0.55 in. Lattice Cell(17)	0.290	0.263	0.416
Saxton Criticals 0.80 in. Lattice Cell(18)	0.236	0.195	
Saxton Criticals 0.52 in. Lattice Cell(18)	0.193	0.164	

INPUT INSTRUCTIONS

This section describes the input instructions for BRT-I. The following units are used throughout the input:

Cross sections	- barns
Concentrations	- nuclei per barn.cm
Speed	- 2200 m/sec
Mass	- neutron mass units
Temperature	- 293.6 °K
Dimensions	- centimeters

PROBLEM IDENTIFICATION AND BYPASS

Card No.	Format	Variable Entry	Description
Card 1	(72H)	---	72 Hollerith character identification with a one in Column 1 for program control of printer.
Card 2	(3I5)	IDENT,	Identification number. If negative or zero, program exits.
		IBY	Bypass, normally zero. If > 0, the cross sections used for the last case will be used again. If < 0, the edit from the last case will be repeated with new parameters.
		NTLIBE	Tape unit library mounted on (normally 8).

Note: If IBY > 0, go to Card 29. If IBY < 0, go to Card 33.

PROBLEM SIZE AND CONTROL

Card No.	Format	Variable Entry	Description
Card 3	(10I5)	NX,	Number of space points ≤ 30
		IX,	Number of speed points < 30
		MX,	Number of mixtures ≤ 8
		ISOX,	Number of isotopes used in. cell from library*
		ISOXE,	Number of isotopes used in edit from library*
		ICX,	Number of isotopes used in cell not from library*
		ICXE,	Number of isotopes used in edit not from library*

* *The only restriction on this is that ISOX + ICX + ISOXE + ICXE ≤ 30.*

Card No.	Format	Variable Entry	Description
Card 3 Cont'd		NANI	= 1 for anisotropy correction to the scattering kernel and cross section of each material used in the cell.
		NRSMR	Number of external source data sets to be read.
		NBUCK	Type of transverse buckling (NBUCK = 0/1/2/3, $B^2 = 0 / B_z^2 / B_z^2+B_y^2 / B_R^2$)

TRANSVERSE BUCKLING PARAMETERS

(IGNORE IF NBUCK = 0)

Card No.	Format	Variable Entry	Description
Card 4	(3E10.5)	BF	Buckling factor - i.e., number of extrapolated distances to be added to the transverse buckling dimensions.
		DZ	Cylindrical height, plane height, or cylindrical radius.
		DY	Plane width.

MIXTURE TABLE

Card No.	Format	Variable Entry	Description
Card 5	(3011)	(MTBL(N), N=1,NX)	Mixture number (1-8) assigned to each space point N.

DESCRIPTION OF ISOTOPES USED IN CELL FROM LIBRARY

(IGNORE IF ISOX = 0)

Card No.	Format	Variable Entry	Description
Card 6	2F5.0	WSTBA(J),	First ident of j^{th} isotope used in cell.
		WSTBB(J),	Second ident of j^{th} isotope used in cell.
	(MX)E10.5	(CONCTA(J, M),M=1,MX),	Concentration of the j^{th} isotope used in the cell in the M^{th} mixture.
	1E10.5	AMAS(J)	Isotope mass used in mubar calculation if first moment kernel is not available.
	Repeat Card 6 for J = 1, ISOX		

DESCRIPTION OF ISOTOPES USED IN EDIT FROM LIBRARY

(IGNORE IF ISOXE = 0)

Card No.	Format	Variable Entry	Description
Card 7	2F5.0	WSTBA(J),	First ident of j^{th} isotope used in edit.
		WSTBB(J),	Second ident of j^{th} isotope used in edit.
	1E10.5	CONCTA(J)	Concentration of j^{th} isotope used in edit.
	Repeat Card 7 for J = 1, ISOXE		

Card No.	Format	Variable Entry	Description

SPEED MESH

(IF ISOX + ISOXE ≠ 0, IGNORE THIS ITEM.)

Card No.	Format	Variable Entry	Description
Card 8	(7E10.5)	((1,I=1,IX)	Speed mesh points, v_i, in increasing order. Repeat Card 8 as many times as necessary.
Card 9	(7E10.5)	((11 11	Integration weights for speed mesh. Repeat Card 9 as many times as necessary.

DESCRIPTION OF ISOTOPES USED IN CELL NOT FROM LIBRARY

(IGNORE IF ICX = 0)

Card No.	Format	Variable Entry	Description
Card 10	2F5.0	WSTBA(LP),	First ident of the LP^{th} isotope used in cell.
		WSTBB(LP),	Second ident of the LP^{th} isotope used in cell.
	(MX)E10.5	CONCTA(LP,M), M = 1,MX),	Concentration of the LP^{th} isotope used in Mixture M.
	1E10.5	AMAS(LP)	Mass of the LP^{th} isotope.
Card 11	2I5	NXAT,	If (NXAT = 0) tabular input If (NXAT # 0) σ_a and σ_f are 1/v, and a_s is constant.
		NKERT	Scattering input indicator. If (NKERT = -2) $P(v' \rightarrow v)$, $\sigma_{so}(v)$, and $\sigma_{s1}(v)$ are tabular. If (NKERT = -1) $P(v' \rightarrow v)$ and $\sigma_s(v)$ are tabular.

Card No.	Format	Variable Entry	Description
Card 11 Cont'd		NKERT Cont'd	If (NKERT = 0) $\sigma_{so}(v)$ is tabular. $P(v \rightarrow v) = \sigma_{so}(v)$ and $P(v' \rightarrow v) = 0$ for $v' \neq v$. If (NKERT > 0) $P(v' \rightarrow v)$ and $\sigma_{so}(v)$ are calculated internally. NKERT is then the number of terms in the sum of exponentials in the Brown St. John Gas Model.
	1E10.5	TP	Temperature of LP$^{\underline{th}}$ isotope for the calculation of the scattering kernel. Ignore if NKERT ≤ 0.
	3A6	(HOLC(J), J=1,3)	Alphanumeric identification of LP$^{\underline{th}}$ isotope.

If (NXAT ≠ 0) all LP$^{\underline{th}}$ isotope's cross sections are input here

Card 12	(7E10.5)	VALXA	σ_a = VALXA/V(I), I = 1,IX
		VALXF	σ_f = VALXF/V(I), I = 1,IX
		VNU	ν = VNU
		VALXS	σ_s = VALXS, I = 1,IX

If (NXAT = 0) all cross sections for the LP$^{\underline{th}}$ isotope are input here

Card 13	(7E10.5)	(XA(I),I=1,IX)	Tabular absorption cross sections. Repeat Card 13 as many times as necessary.
Card 14	(7E10.5)	(XF(I),I=1, IX)	Tabular fission cross sections. Repeat Card 14 as many times as necessary.
Card 15	1E10.5	VNU	Average ν for thermal fission.

Card No.	Format	Variable Entry	Description
	If (NKERT > 0) Skip to Card 19		
Card 16	(7E10.5)	((PP(I,J), I=1,IX), J=1,IX)	Tabular scattering kernel values. (Neglect if NKERT > -1).
Card 17	(7E10.5)	(XS(I),I=1, IX)	Tabular scattering cross-section values. (Neglect if NKERT > 0).
Card 18	(7E10.5)	(XS1(I), I=1,IX)	Tabular 1st moment scattering cross-section values. (Neglect if NKERT > -2).
	Ignore Card 19 if NKERT ≤0		
Card 19	(3E10.5)	AT(N),	Cross-section σ_n used in the $n^{\underline{th}}$ term of the $LP^{\underline{th}}$ isotope scattering kernel.
		AMT(N),	Mass used in $n^{\underline{th}}$ term of $LP^{\underline{th}}$ isotope scattering kernel.
		AKT(N)	Value χ_n used in $n^{\underline{th}}$ term of $LP^{\underline{th}}$ isotope scattering kernel.
	Repeat Card 19 for N = 1, NKERT		

Note: Cards 10 through 19, as needed, are repeated ICX times so that LP = ISOX+1,ISOX + ICX.

DESCRIPTION OF ISOTOPES USED IN EDIT NOT FROM LIBRARY

(IGNORE IF ICXE = 0)

Card No.	Format	Variable Entry	Description
Card 20	2F5.0	WSTBA(J),	First ident of $J^{\underline{th}}$ isotope used in edit.
		WSTBB(J),	Second ident of $J^{\underline{th}}$ isotope used in edit.

Card No.	Format	Variable Entry	Description
Card 20 Cont'd	1E10.5	CONCTA(J)	Concentration of J^{th} isotope used in edit.
Card 21	215	NXAT	If zero, σ_a for the J^{th} isotope is tabular. If non-zero, a_a is 1/v.
		NXAF	If zero, σ_f for the J^{th} isotope is tabular. If non-zero, σ_f is 1/v.
	2E10.5	VALXA	If NXAT ≠ 0, $\sigma_a(v)$ = VALXA/v.
		VALXF	If NXAF # 0, $\sigma_f(v)$ = VALXF/v.
	3A6	(HOLID(K,J) K=1,3)	Alphanumeric identification of the J^{th} isotope.
Card 22	(7E10.5)	(XAT(J,I), I = 1,IX)	Tabular microscopic absorption cross section of the J^{th} isotope. Ignore if NXAT ≠ 0.
Card 23	(7E10.5)	(XFT(J,I), I = 1, IX)	Tabular microscopic fission cross section of the J^{th} isotope. Ignore if NXAF ≠ 0.

Note: Cards 20 through 23, as needed, are repeated ICXE times so that J = ISOXE+1, ISOXE+ICXE.

Card No.	Format	Variable Entry	Description
		SLOWING DOWN SOURCE DATA	
Card 24	(3I5)	NSC,*	Number of Cards 26 required for source definition.
		NST	If ≤ 0, a spatially flat source is used. If > 0, the distribution $S_d(r_i)$ is read.
		NPRNT	If non-zero the unnormalized source is printed out.
	Ignore Card 24 if NST ≤ 0		
Card 25	(7E10.5)	(SD(N), N=1,NX)	Spatial source distribution $S_d(r_i)$. Repeat Card 24 as many times as necessary.
Card 26	I5	M	Mixture number (1-8) in which this source is used.
	4E10.5	AM,	Mass used in the calculation of this source.
		HXS,	Microscopic high energy cross for source.
		HCON,	Concentration of isotope for this source.
		TP	Effective temperature of protons. If this error function correction is not used, TP = 0.
	External Source Data (Neglect if NRSMR = 0)		
Card 27	I5	M	Mixture to which this source is assigned.
	E12.5	HCON	Concentration of this source in Mixture M.

* *Normally = 0 since the source for library isotopes is stored on the library tape. If ≠ 0, these sources are added on to those from tape. Card 26 is repeated until NSC cards have been read.*

Card No.	Format	Variable Entry	Description
Card 28	(7E10.5)	(SP(I), I=1,IX)	Input source for Mixture M.

Cards 27 and 28 are repeated NRSMR times.

GEOMETRY DATA FOR EITHER SLAB OR CYLINDRICAL GEOMETRY

Card No.	Format	Variable Entry	Description
Card 29	(7I5)	LEAKT,	a. < 0, Full slab with vacuum boundaries. b. = 0, Cylinder or half slab. Vacuum or white albedo boundary. c. = 1, slab or cylinder with reflecting boundaries.
		NXA,	Number of regions.
		NGEOM,	a. = 1, Regular cylindrical geometry with Argonne corrections. b. = 2, Fast cosine currents; cylindrical geometry; from SRL. c. = 3, Regular slab geometry with Argonne corrections. d. = 4, Fast cosine currents; slab geometry; from SRL.
		NCUR	a. = 0, Current calculation using T matrix. b. = 1, Current calculation utilizing flux gradient calculation. c. ≠ 0, 1 Current set equal to the flux.

Card No.	Format	Variable Entry	Description
Card 29 (contd)		NPSMR,	a. = 0, Suppresses cell smear option. b. = 1, Writes out and gives punched card input to a later case. c. > 1, Suppresses card output
		MICROP,	a. = 0, Suppress disadvantage factor option. b. = 1, IX group flux disadvantage factors are written and punched out for each region. c. > 1, Suppress card output.
		NAX,	Neglect if LEAKT ≠ 0. a. < 0, Speed dependent albedoes. b. = 0, Vacuum boundary. c. > 0, Constant albedo.
	1E10.5	CONA	Value of constant albedo. ALBEDO(I) = CONA, I = 1,IX.

Cell Boundardy Input Data (Ignore unless LEAKT = 0, NGEOM = 1, and NAX ≠ 0)

Card No.	Format	Variable Entry	Description
Card 30	I10	NBGEOM	Boundary geometry indicator = (0/1/2 → Cyl/Rect/Hex).
	2E10.5	P1,P2	Cell pitch(es)

	NBGEOM = 0	1	2
P1	NA	X	Z
P2	NA	Y	NA

Card No.	Format	Variable Entry	Description

ALBEDO INPUT

(IGNORE UNLESS LEAKT = 0 AND NAX < 0)

Card No.	Format	Variable Entry	Description
Card 31	(7E10.5)	ALBEDO(I), I=1,IX	Right-hand boundary albedoes. Repeat Card 31 as many times as necessary.

REGION INPUT

Card No.	Format	Variable Entry	Description
Card 32	2I5	NR	Region number in increasing order.
		NP	Number of space points in this region.
	E10.5	TH	Thickness of this region.

Card 32 is repeated until NXA cards have been read.

ITERATION PARAMETERS

Card No.	Format	Variable Entry	Description
Card 33	5E10.5,	EPS,	Neutron density convergence criterion, $\varepsilon_r (= 10^{-5})$.
		RELC,	Initial overrelaxation factor, $\omega_o (= 1.2)$. (If the anisotropy scattering is made RELC = 1.0)
		EPSG,	Extrapolation criterion, $\varepsilon_e (= 0.05)$.
		OVERX, .	Maximum extrapolation factor (= 100).
		FACTOR	Under extrapolation factor (= 1.00).
	415	ITBG,	Minimum iterations before extrapolation, $\ell_b (= 5)$. (If anisotropy corr. ITBG = ITMAX + 1 shuts off all extrapolation.)

Card No.	Format	Variable Entry	Description
Card 33 (contd)		LCMX,	Number of overrelaxation factors tested, ℓ_e(= 5).
		ITDM,	Minimum delay between extrapolations, ℓ_d(= 5).
		ITMAX	Maximum number of iterations allowed (= 100).
	I2	IPT	If > 0, record of each iteration is printed (= 1). If < 0, print is omitted.

If ITMAX ≤ 0, the values in parentheses will be used.

EDIT DATA

Card No.	Format	Variable Entry	Description
Card 34	1I5	IXPCM,	Number of energy intervals over which edit is desired ≤ 5. If more edits are desired, see Card 2.
	2I5	(NLOW(J), IXPT(J), J = 1, IXPCM)	Index of lower bound for edit integral. Index of upper bound for edit integral. These indices are input in pairs LOWER - UPPER cutoff.

Repeat variables NLOW(J) and IXPT(J), in pairs, on Card 34 for J = 1, IXPCM.

Card No.	Format	Variable Entry	Description
Card 35	(30I1)	(NRTBL(N), N = 1,NX)	An integer (<10) is assigned to each space point. A sequence of the same integer defines an edit region. Spatial averages are done in an edit region.

Card No.	Format	Variable Entry	Description

TERMINATION

If more cases are to be done, return to Card 1. If exit from BRT-I is desired, use the following cards.

Card 36	(72H)	----	72 Hollerith character card indicating that cases are complete
Card 37	----	----	Blank card.

OUTPUT EDIT

Since the output edit has been extensively modified with respect to the original THERMOS code, the quantities printed out in BRT-I are explicitly defined below in order of their occurrence. The output edit is divided into three main sections. Distributions-and-averages of both space and energy are listed in the first section. In this section the spacial averaging is determined by the cell composition; i.e., the mixture regions.

The second section is called "Materials Used in the Cell," where the desired broad speed group, microscopic and macroscopic averages are listed for the edit regions specifically defined in the input (Card 35) independent of the physical regions.

The last section entitled "Materials Used for Editing Purposes," produces point and region averaged absorption-and fission cross sections and relative reaction rates. The region averaging in this section is controlled by the mixture regions. The defined edit quantities are mostly self-explanatory, if the following definitions are kept in mind.

V_n = the volume associated with space point n.

v_I = the midpoint of fine speed Group I.

V_K = the volume of Region K.

v_U, v_L = the upper and lower speed boundaries for a given broad group.

OR_K = outer dimension of Region K.

A complete edit is produced for each broad group, where v_U and v_L are specified in the input in pairs for a maximum of 5 broad groups. (Card 34)

CELL COMPOSITIONS (UNLABLED)

Energy Distributions (by Mixture Region)

POINT	REG	MIX	SPEED	NDEN * VOL	NFLUX * VOL	ABSORPTION
I	K	M	v_I	$\int_I dv \int_K d\underline{r}\; N(\underline{r},v)$	$\int_I dv \int_K d\underline{r}\; vN(\underline{r},v)$	$\int_I dv \int_K d\underline{r}\; \Sigma_a(\underline{r},v)\; vN(\underline{r},v)$
SUM	VOLUME	=	V_K	$\int_{v_L}^{v_U} dv \int_K d\underline{r}\; N(\underline{r},v)$	$\int_{v_L}^{v_U} dv \int_K d\underline{r}\; vN(\underline{r},v)$	$\int_{v_L}^{v_U} dv \int_K d\underline{r}\; \Sigma_a(\underline{r},v)\; vN(\underline{r},v)$
AVE				$\frac{1}{V_K}\int_{v_L}^{v_U} dv \int_K d\underline{r}\; N(r,v)$	$\frac{1}{V_K}\int_{v_L}^{v_U} dv \int_K d\underline{r}\; vN(\underline{r},v)$	$\frac{1}{V_K}\int_{v_L}^{v_U} dv \int_K d\underline{r}\; \Sigma_a\; (\underline{r},v)\; vN(\underline{r},v)$

POINT	SCATTERING	FISSIONS
I	$\int_I dv \int_K d\underline{r}\; \Sigma_{S_o}\; (\underline{r},v)\; vN(\underline{r},v)$	$\int_I dv \int_K d\underline{r}\; \Sigma_f\; (\underline{r},v)\; vN(\underline{r},v)$
SUM	$\int_{v_L}^{v_U} dv \int_K d\underline{r}\; \Sigma_{S_o}\; (\underline{r},v)\; vN(\underline{r},v)$	$\int_{v_L}^{v_U} dv \int_K d\underline{r}\; \Sigma_f\; (\underline{r},v)\; vN(\underline{r},v)$
AVE	$\frac{1}{V_K}\int_{v_L}^{v_U} dv \int_K d\underline{r}\; \Sigma_{S_o}\; (\underline{r},v)\; vN(\underline{r},v)$	$\frac{1}{V_K}\int_{v_L}^{v_U} dv \int_K d\underline{r}\; \Sigma_f\; (\underline{r},v)\; vN(\underline{r},v)$

POINT	NBAR[a]	MID ENERGY
I	$\frac{1}{V_K} \int_K d\underline{r}\ N(\underline{r},v)$	$0.0253\ v_I^2$ ev
SUM	----	----
AVE.	----	----

---

a. $\bar{N}(v) = 2KT_o\ \bar{\phi}(E)$, *where* $2KT_o = 0.0506$ *eV, and* $\bar{\phi}(E)$ *is in units of* n/cm^2 *sec/eV.*

Space Distributions (by Broad Group)

POINT	REG	MIX	VOLUME	NDEN * VOL	NFLUX * VOL	ABSORPTION
n	K	M	V_n	$V_n \int_{v_L}^{v_U} dv\; N(\underline{r},v)$	$V_n \int_{v_L}^{v_U} dv\; vN(\underline{r},v)$	$V_n \int_{v_L}^{v_U} dv\; \Sigma_a(\underline{r},v)\; vN(\underline{r},v)$
SUM	K	M	$V_K = \int_K d\underline{r}$	$\int_K d\underline{r} \int_{v_L}^{v_U} dv\; N(\underline{r},v)$	$\int_K d\underline{r} \int_{v_L}^{v_U} dv\; vN(\underline{r},v)$	$\int_K d\underline{r} \int_{v_L}^{v_U} dv\; \Sigma_a(\underline{r},v)\; vN(\underline{r},v)$
V AVE	K	M		$\frac{1}{V_K} \int_K d\underline{r} \int_{v_L}^{v_U} dv\; N(\underline{r},v)$	$\frac{1}{V_K} \int_K d\underline{r} \int_{v_L}^{v_U} dv\; vN(\underline{r},v)$	$\frac{1}{V_K} \int_K d\underline{r} \int_{v_L}^{v_U} dv\; \Sigma_a(\underline{r},v)\; vN(r,v)$

POINT	REG	MIX	SCATTERING	FISSIONS
n	K	M	$V_n \int_{v_L}^{v_U} dv\; \Sigma_{S_o}(\underline{r},v)\; vN(\underline{r},v)$	$V_n \int_{v_L}^{v_U} dv\; \Sigma_f(\underline{r},v)\; vN(\underline{r},v)$
SUM	K	M	$\int_K d\underline{r} \int_{v_L}^{v_U} dv\; \Sigma_{S_o}(\underline{r},v)\; vN(\underline{r},v)$	$\int_K d\underline{r} \int_{v_L}^{v_U} dv\; \Sigma_f(\underline{r},v)\; vN(\underline{r},v)$
V AVE	K	M	$\frac{1}{V_K} \int_K d\underline{r} \int_{v_L}^{v_U} dv\; \Sigma_{S_o}(\underline{r},v)\; vN(\underline{r},v)$	$\frac{1}{V_K} \int_K d\underline{r} \int_{v_L}^{v_U} dv\; \Sigma_f(\underline{r},v)\; vN(\underline{r},v)$

POINT	REG	MIX	AVE V	AVE V**2	AVE V**3
n	K	M	$\dfrac{\int_{v_L}^{v_U} dv\ vN(\underline{r},v)}{\int_{v_L}^{v_U} dv\ N(\underline{r},v)}$	$\dfrac{\int_{v_L}^{v_U} dv\ v^2N(\underline{r},v)}{\int_{v_L}^{v_U} dv\ N(\underline{r},v)}$	$\dfrac{\int_{v_L}^{v_U} dv\ v^3N(\underline{r},v)}{\int_{v_L}^{v_U} dv\ N(\underline{r},v)}$
SUM	K	M	-----	-----	-----
V AVE	K	M	$\dfrac{\int_K d\underline{r} \int_{v_L}^{v_U} dv\ vN(\underline{r},v)}{\int_K d\underline{r} \int_{v_L}^{v_U} dv\ N(\underline{r},v)}$	$\dfrac{\int_K d\underline{r} \int_{v_L}^{v_U} dv\ v^2N(\underline{r},v)}{\int_K d\underline{r} \int_{v_L}^{v_U} dv\ N(\underline{r},v)}$	$\dfrac{\int_K d\underline{r} \int_{v_L}^{v_U} dv\ v^3N(\underline{r},v)}{\int_K d\underline{r} \int_{v_L}^{v_U} dv\ N(\underline{r},v)}$

POINT	REG	MIX	NFLUX
n	K	M	$\int_{v_L}^{v_U} dv\ vN(\underline{r},v)$
SUM	K	M	-----
V AVE	K	M	-----

MATERIAL USED IN CELL

Microscopic Constants (for each material used in the cell)

REG	MIX[a]	DENSITY	PARTIAL DENSITY	ALL CROSS SECTIONS[b]	D
K	M	$\frac{1}{V_K}\int_K d\underline{r}\ N(\underline{r})$	$\frac{1}{V_{Cell}}\int_K d\underline{r}\ N(\underline{r})$	$\dfrac{\int_K d\underline{r}\int_{v_L}^{v_U} dv\ \Sigma(\underline{r},v)\ \lvert\phi_i(\underline{r},v)\rvert \Big/ \int_K d\underline{r}\ N(\underline{r})}{\frac{1}{V_K}\int_K d\underline{r}\int_{v_L}^{v_U} dv\ \lvert\phi_i(\underline{r},v)\rvert}$	$1/3\bar{\sigma}_{tr}$
REG	SMEAR	VALUES	$\dfrac{\int_{Cell} d\underline{r}\ N(r)\int_{v_L}^{v_U} dv\ \phi_o(\underline{r},v)}{\int_{cell} d\underline{r}\int_{v_L}^{v_U} dv\ \phi_o\ (\underline{r},v)}$	$\dfrac{\int_{Cell} d\underline{r}\int_{v_L}^{v_U} dv\ \Sigma(r,v)\ \lvert\phi_i\ (\underline{r},v)\rvert}{\int_{Cell} d\underline{r}\ N(\underline{r})\int_{v_L}^{v_U} dv\ \lvert\phi_i\ (\underline{r},v)\rvert}$	$1/3\bar{\sigma}_{tr}$
Cell	SMEAR	VALUES	$\frac{1}{V_{cell}}\int_{Cell} d\underline{r}\ N(\underline{r})$	$\dfrac{\int_{Cell} d\underline{r}\int_{v_L}^{v_U} dv\ \Sigma(\underline{r},v)\ \lvert\phi_i(r,v)\rvert \Big/ \int_{Cell} d\underline{r}\ N(\underline{r})}{\frac{1}{V_{Cell}}\int_{Cell} d\underline{r}\int_{v_L}^{v_U} dv\ \lvert\phi_i(\underline{r},v)\rvert}$	$1/3\bar{\sigma}_{tr}$

a. *If the specified edit region includes more than one mixture region the mixture printed out is set equal to ten plus the mixture number at the outermost space point in the edit region.*

b. Σ *denotes* $\Sigma_a, \Sigma_f, \nu\Sigma_f, \Sigma_{S_0}, \Sigma_{S_1}$, *and* $\Sigma_{tr} = \Sigma_a + \Sigma_{S_0} - \Sigma_{S_1}$. *The* Σ_a, Σ_f, $\nu\Sigma_f$, *and* Σ_{S_0} *cross sections are flux* (ϕ_0) *weighted and the* Σ_{S_1} *and* Σ_{tr} *cross sections are current* (ϕ_1) *weighted.*

Macroscopic Constants

REG	RADIUS	VOLUME FRACTION	FLUX (ϕ_0) & CURRENT (ϕ_1) DEPRESSION	INVERSE VELOCITY	D*CURRENT[a]
K	OR_K	$\frac{V_K}{V_{Cell}}$	$\frac{\frac{1}{V_K}\int_K d\underline{r}\int_{v_L}^{v_U} dv \left\|\phi_i(\underline{r},v)\right\|}{\frac{1}{V_{Cell}}\int_{Cell} d\underline{r}\int_{v_L}^{v_U} dv \left\|\phi_i(\underline{r},v)\right\|}$	$\frac{\int_K d\underline{r}\int_{v_L}^{v_U} dv(\frac{1}{v})\ \phi_o(\underline{r},v)}{\int_K d\underline{r}\int_{v_L}^{v_U} dv\ \phi_o(\underline{r},v)}$	$\frac{1}{3<\Sigma_{tr}>_K}$
Cell Smear Values		1.0	1.0	$\frac{\int_{Cell} d\underline{r}\int_{v_L}^{v_U} dv(\frac{1}{v})\ \phi_o(\underline{r},v)}{\int_{Cell} d\underline{r}\int_{v_L}^{v_U} dv\ \phi_o(\underline{r},v)}$	$\frac{1}{3<\Sigma_{tr}>_{Cell}}$

REG	ALL CROSS SECTIONS	D*FLUX[b]
K	$\frac{\int_K d\underline{r}\int_{v_L}^{v_U} dv\ \Sigma(\underline{r},v)\left\|\phi_i(\underline{r},v)\right\|}{\int_K d\underline{r}\int_{v_L}^{v_U} dv\left\|\phi_i(\underline{r},v)\right\|}$	$\left\langle\frac{1}{3\Sigma_{tr}}\right\rangle_K$
Cell SMEAR	$\frac{\int_{Cell} d\underline{r}\int_{v_L}^{v_U} dv\ \Sigma(\underline{r},v)\left\|\phi_i(\underline{r},v)\right\|}{\int_{Cell} d\underline{r}\int_{v_L}^{v_U} dv\left\|\phi_i(\underline{r},v)\right\|}$	$\left\langle\frac{1}{3\Sigma_{tr}}\right\rangle_{Cell}$

a. *The diffusion coefficient defined as one over three times the current (ϕ_1) weighted Σ_{tr}.*

b. *The flux (ϕ_0) weighted diffusion coefficient where D is defined as one over 3 times Σ_{tr}.*

Materials Used for Editing Purposes

POINT	REG	MIX	SIGMA A	REL ACT
n	K	M	$\dfrac{\int_{v_L}^{v_U} dv\ \Sigma_a(\underline{r},v)\ vN(\underline{r},v)}{\int_{v_L}^{v_U} dv\ \ vN(\underline{r},v)}$	$\dfrac{\int_{v_L}^{v_U} dv\ \Sigma_a(\underline{r},v)\ vN(\underline{r},v)}{\left[\int_{v_L}^{v_U} dv\ \Sigma_a(\underline{r},v)\ vN(\underline{r},v)\right]_{n=1}}$
AVE	K	M	$\dfrac{\int_K d\underline{r}\ \int_{v_L}^{v_U} dv\ \Sigma_a(\underline{r},v)\ vN(\underline{r},v)}{\int_K d\underline{r}\ \int_{v_L}^{v_U} dv\ vN(\underline{r},v)}$	$\dfrac{\frac{1}{V_K}\int_K d\underline{r}\ \int_{v_L}^{v_U} dv\ \Sigma_a(\underline{r},v)\ vN(r,v)}{\left[\int_{v_L}^{v_U} dv\ \Sigma_a(\underline{r},v)\ vN(r,v)\right]_{n=1}}$

POINT	REG	MIX	SIGMA F	REL ACT
n	K	M	Same as above definitions	
AVE	K	M	with Σ_a replaced by Σ_f	

LIBRARY PREPARATION INSTRUCTIONS

This section describes the Code RLITHE(3,5,19) (Revised Library for Thermal Energies) used to prepare or list a cross-section library tape or random access data element for BRT-I. The program accepts absorption and fission cross sections as constant, 1/v, or tabulated. Scattering cross sections and kernels may be either input on octal decks or computed from the Brown-St. John form of the free gas kernel. In the free gas model the cross section is described by

$$\sigma_s(v_r) = \sum_{n=1}^{NTERM} A_n e^{-\kappa_n v_r^2}$$

where v_r is the relative velocity, and A_n, κ_n, and M_n (the mass) are input parameters.

The units used are:

Cross sections - barns,
Speed - 2200 m/sec,
Temperature - °K.

STRUCTURE OF THE BINARY TAPE LIBRARY

The first record on the tape library contains

IX, HOL, V, DV

where IX is the number of speed groups,

HOL is an 18-character (3 word) library identification,
V are the speed points (IX words), and
DV are the speed increments (IX words).

The second record contains

WA, WB, HOLB, NKERN, VNU, XA, XS, XF, S

where WA is the isotope identification number,

- WB is the temperature and model index,
- HOLB is an 18-character (3 word) isotope identification,
- NKERN is the number of Legendre components of the scattering kernel included (≤ 4),
- VNU is the value of ν (neutrons/fission),
- XA are the absorption cross sections at each speed (IX words),
- XS are the scattering cross sections at each speed (IX words),
- XF are the fission cross sections at each speed (IX words), and
- S are the slowing down sources into each group (IX words).

The next few records contain the Legendre components of the scattering kernel in the form

$$P_{nij} = 4\pi(0.0253)v_i v_j \Delta v_j \int_{-1}^{1} d\mu p_n(\mu) \frac{d\sigma(E_i \leftarrow E_j, \mu)}{d\Omega d\varepsilon}$$

where $p_n(\mu)$ is the Legendre polynomial.

If NKERN = 0, no kernels are used and no records written.

If NKERN = 1, the isotropic (P_o) component is used and one record written.

If NKERN = 2, the isotropic (P_o) component and P_1 component are used and two records written, etc.

The pattern is repeated from the second record for each isotope. The last record is similar to the second record but WA $\leq$ 0 and signals the end of the tape.

STRUCTURE OF THE RANDOM ACCESS DATA ELEMENT

The random access data element is similar in structure to the Binary Library Tape.

The first record of the Random Access Data File contains an additional word, NISO, which is the total number of isotopes in the library. The structure of this record is IX, NISO, HOL, V, and DV.

The second record is an additional record, not present in the tape library, of the isotope identification numbers and location within the data element. The second record structure is first identification number, second identification number, and address of the data record for each of the NISO isotopes.

The third and succeeding records are identical to the 2nd, 3rd, etc., records on the library tape.

LOGICAL UNIT REQUIREMENTS FOR RLITHE

Logical Unit	Description
5	Normal input
6	Normal output
7	New library tape or scratch unit*
8	Old library tape
26	Scratch drum file on FH432

* *Needed even if just obtaining a library listing without an update.*

RLITHE INPUT INSTRUCTIONS

Card 1

Columns	Format	Symbol	Description
1-18	3A6	HOL	18-character description of tape.
21-26	A6	NAME	Name of random access data element.
31-36	A6	VERSION	Version of random access data element.

Card 2

Columns	Format	Symbol	Description
1-5	(I5,	ITAG	= 0 Make a new library from cards. < 0 Update an existing tape library. > 0 Update an existing random access library.
6-10	I5,	IX	Number of speed groups (≤30).
11-15	I5,	NISD	Number of isotopes to be deleted from existing library (≤100).
16-20	I5,	ITYPE	≤ 0 Output library in random access form. > 0 Output library in tape form.
21-25	I5)	ILIST	= 0 No Listing of isotopes from existing library. > 0 List ILIST number of isotopes to be specified on Card Type 6 < 0 List all isotopes on existing library.

Columns	Format	Symbol	Description
		Card 3	
---	7E10.5	V(I), I=1,IX	The speed points in increasing order. Omit if ITAG $\neq$ 0.
		Card 4	
---	7E10.5	DV(I), I=1,IX	Speed increments. Omit if ITAG $\neq$ 0.
		Card 5	
1-10	E10.0	(WAP(L),	Identification number and
11-20	E10.0	WBP(L),	temperature/model index for isotopes to be deleted.
		L=1, NISD)	One card/isotope. Omit if NISD = 0.
		Card 6	
1-5	(2F5.0)	(WSTBA(N)	First ident of N^{th} isotope to be listed from existing library.
6-10		WSTBB(N) N=1, ILIST)	Second ident of N^{th} isotope to be listed from existing library. Omit if ILIST $\leq$ 0
		Card 7	
1-18	3A6	HOLB	18-character description of isotope.
21-30	F10.0	WA	Isotope identification number.
31-40	F10.0	WB	Temperature/model index.
41-45	I5	LXA	= 0 $\sigma_a(v)$ = VXA (see Card 8) = 1 $\sigma_a(v)$ = VXA/v (see Card 8) = 2 $\sigma_a(v)$ tabulated.

Columns	Format	Symbol	Description
Card 7 Cont'd			
46-50	I5	LXS	= 0 $\sigma_s(v)$ = VXS (see Card 8) = 1 $\sigma_s(v)$ computed from gas model. = 2 $\sigma_s(v)$ computed from input kernel.
51-55	I5	LXF	= 0 $\sigma_f(v)$ = VXF (see Card 8) = 1 $\sigma_f(v)$ = VXF/v (see Card 8) = 2 $\sigma_f(v)$ tabulated.
56-60	I5	NKERN	Number of kernels to be put on tape.
61-65	I5	NTERM	Number of terms in BSJ formula.
		Card 8	
1-10	E10.5	VXA	Value of σ_a.
11-20	E10.5	VXS	Value of σ_s.
21-30	E10.5	VXF	Value of σ_f.
31-40	E10.5	VNU	Value of ν.
41-50	E10.5	AM	Mass used in source calculation (amu).
51-60	E10.5	HXS	Cross section used in source calculation (barns).
61-70	E10.5	TP	Temperature used in source calculation (°K).
		Card 9	
---	7E10.5	(XA(I), I=1,IX)	Tabulated values of σ_a (v_i). Omit if LXA $\neq$ 2.
		Card 10	
---	7E10.5	(XF(I), I=1,IX)	Tabulated values of $\sigma_f(v_i)$. Omit if LXF $\neq$ 2.

Columns	Format	Symbol	Description
		Card 11	
---	(7E10.5)	T,	Temperature (°K) used in the kernel calculation.
		(ZAMT(N),	M_n used in the BSJ formula (amu).
		ZAT(N),	A_n used in the BSJ formula (barns)
		ZAKT(N),	K_n used in the BSJ formula
		N=1, NTERM)	Omit if LXS ≠ 1
		Card 12	
1-5	I5	ICARD	Card sequence number within the P_nth scattering kernel deck (=1).
6-10	I5	IDM	Isotope identification number (WA).
11-15	I5	IDMA	Second identification number (WB).
16-20	I5	IX	Number of speed groups.
21-25	I5	LX	Number of matrix elements to be read in the P_nth kernel deck, LX = IX(IX+1)/2.
26-30	I5	IO	Not used.
31-42	1PE12.4	T	Temperature (°K) Omit if LXS ≠ 2.

Columns	Format	Symbol	Description
		Card 13	
1-5	(I5,	ICARD	Sequence number (≥2).
6-77	6012)	P(I,J)	All of the Pnth scattering kernel elements except the upscatter i.e., ((P_n(I,J), I=1,J), J=1, IX). Omit if LXS ≠ 2.

Note: Cards 12 and 13 are repeated NKERN times for each isotope.

		Card 14	
---	---		Repeat Cards 7-13 for each isotope to be added to the library. Follow last isotope with a blank card to signal end of input data.

ADDITIONAL INSTRUCTIONS FOR UPDATING OR MAKING A NEW RANDOM ACCESS LIBRARY

The random access library as an absolute element, is either punched out on cards or written out to tape by the CUR utility routine. Therefore when updating or making a new random access library the following FORTRAN control cards follow the normal RLITHE input data:

∇ XQT CUR

PCH name/version or TWR unit, name/version

where the name and version are those supplied by the user (Card 1 of the RLITHE input data).

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APPENDIX A

BRT-I TEST CASE

```
'     RUN   CARD
'A   ASG,R A=03654
'    XQT CUR
IN A
TRI A
'    DAT   THERMS/OR9069,0
'   XQT BRT1
1CELL SAMPLE CASE - 2.0 W/O PUO2 IN UO2-PUO2    0.75 INCH SQUARE PITCH
    1     0    8
   LO    30     5     9     0     0     0     1
1111111222333333333
 1001 1029                        6.67348-021.0060
 8000     294.21622-02            5.33674-0215.999
92235     291.50653-04                      235.05
92238     292.05115-02                      238.05
94239     293.83953-04                      239.05
94240     293.19254-05                      240.05
94241     292.90916-06                      241.05
34242     291.24163-07                      242.05
40000     29             4.29100-02         91.220
    0      0     A
    0     3     1     0     0     0     1 1.0
          .0
    1      70.64450+00
    2      30.07620+00
    3     100.35406+00

    1     0    30
1111111222333333333
  END OF SAMPLE CASE
```

UO2-PUO2

```
*****************************
BATTELLE REVISED THERMOS
* RUN ON 16 JUN 70 *
*   AT 16:44:11  *
***** **********
```

```
IDENT      1

SPACE POINTS= 20
GROUPS= 30
MIXTURES=  3
LIBRARY ISOTOPES IN CELL=  9
LIBRARY ISOTOPES IN EDIT=  0
ADDED ISOTOPES IN CELL=  0
ADDED ISOTOPES IN EDIT=  0
ANISOTROPY CORRECTION TO SCATTERING KERNEL= YES
TRANSVERSE BUCKLING CORRECTION =   NO
LIBRARY TAPE LABELED THERMOS LIB RU1330
```

THERMOS CASE NO. 1 PAGE 2

ISOTOPE	IDENT	CONC MIX 1	CONC MIX 2	CONC MIX 3	ATOMIC MASS
USED IN CELL					
1001.	1029.	-0.00000	-0.00000	6.67348-02	1.00800+00
8000.	29.	4.21622-02	-0.00000	3.33674-02	1.59990+01
92235.	29.	1.50653-04	-0.00000	-0.00000	2.35030+02
92238.	29.	2.05115-02	-0.00000	-0.00000	2.38030+02
94239.	29.	3.83953-04	-0.00000	-0.00000	2.39050+02
94240.	29.	3.19254-05	-0.00000	-0.00000	2.40050+02
94241.	29.	2.90916-06	-0.00000	-0.00000	2.41050+02
94242.	29.	1.24163-07	-0.00000	-0.00000	2.42050+02
40000.	29.	-0.00000	4.29100-02	-0.00000	9.12200+01

REGION NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
MIXTURE NO	1	1	1	1	1	1	1	2	2	2	3	3	3	3	3	3	3	3	3	3

SOURCE DATA

NO. OF CARDS= 0

SPACE DIST

1.00000+00	1.00000+00	1.00000+00	1.00000+00	1.00000+00
1.00000+00	1.00000+00	1.00000+00	1.00000+00	1.00000+00
1.00000+00	1.00000+00	1.00000+00	1.00000+00	1.00000+00
1.00000+00	1.00000+00	1.00000+00	1.00000+00	1.00000+00

THERMOS CASE NO. 1 PAGE 3

SOURCE DISTRIBUTION

I	S(1,I)	S(2,I)	S(3,I)	S(4,I)	S(5,I)	S(6,I)	S(7,I)	S(8,I)	S(9,I)	S(10,I)
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
7	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
8	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
10	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
11	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
12	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
13	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
14	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
15	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
17	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
21	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
22	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
23	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
24	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
25	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
26	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
27	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
28	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
29	1.78939-03	1.78939-03	1.78939-03	1.78939-03	1.78939-03	1.78939-03	1.78939-03	0.00000	0.00000	0.00000
30	5.81045-03	5.81045-03	5.81045-03	5.81045-03	5.81045-03	5.81045-03	5.81045-03	2.88221-03	2.88221-03	2.88221-03

THERMOS CASE NO. 1 PAGE 4

SOURCE DISTRIBUTION

I	S(11,I)	S(12,I)	S(13,I)	S(14,I)	S(15,I)	S(16,I)	S(17,I)	S(18,I)	S(19,I)	S(20,I)
1	4.23908-03	4.23908-03	4.23908-03	4.23908-03	4.23908-03	4.23908-03	4.23908-03	4.23908-03	4.23908-03	4.23908-03
2	1.12333-02	1.12333-02	1.12333-02	1.12333-02	1.12333-02	1.12333-02	1.12333-02	1.12333-02	1.12333-02	1.12333-02
3	1.65921-02	1.65921-02	1.65921-02	1.65921-02	1.65921-02	1.65921-02	1.65921-02	1.65921-02	1.65921-02	1.65921-02
4	2.16218-02	2.16218-02	2.16218-02	2.16218-02	2.16218-02	2.16218-02	2.16218-02	2.16218-02	2.16218-02	2.16218-02
5	2.62488-02	2.62488-02	2.62488-02	2.62488-02	2.62488-02	2.62488-02	2.62488-02	2.62488-02	2.62488-02	2.62488-02
6	3.04388-02	3.04388-02	3.04388-02	3.04388-02	3.04388-02	3.04388-02	3.04388-02	3.04388-02	3.04388-02	3.04388-02
7	3.41585-02	3.41585-02	3.41585-02	3.41585-02	3.41585-02	3.41585-02	3.41585-02	3.41585-02	3.41585-02	3.41585-02
8	3.74006-02	3.74006-02	3.74006-02	3.74006-02	3.74006-02	3.74006-02	3.74006-02	3.74006-02	3.74006-02	3.74006-02
9	4.01726-02	4.01726-02	4.01726-02	4.01726-02	4.01726-02	4.01726-02	4.01726-02	4.01726-02	4.01726-02	4.01726-02
10	4.25171-02	4.25171-02	4.25171-02	4.25171-02	4.25171-02	4.25171-02	4.25171-02	4.25171-02	4.25171-02	4.25171-02
11	4.44174-02	4.44174-02	4.44174-02	4.44174-02	4.44174-02	4.44174-02	4.44174-02	4.44174-02	4.44174-02	4.44174-02
12	4.59272-02	4.59272-02	4.59272-02	4.59272-02	4.59272-02	4.59272-02	4.59272-02	4.59272-02	4.59272-02	4.59272-02
13	4.71244-02	4.71244-02	4.71244-02	4.71244-02	4.71244-02	4.71244-02	4.71244-02	4.71244-02	4.71244-02	4.71244-02
14	4.80425-02	4.80425-02	4.80425-02	4.80425-02	4.80425-02	4.80425-02	4.80425-02	4.80425-02	4.80425-02	4.80425-02
15	4.87315-02	4.87315-02	4.87315-02	4.87315-02	4.87315-02	4.87315-02	4.87315-02	4.87315-02	4.87315-02	4.87315-02
16	4.92596-02	4.92596-02	4.92596-02	4.92596-02	4.92596-02	4.92596-02	4.92596-02	4.92596-02	4.92596-02	4.92596-02
17	4.96634-02	4.96634-02	4.96634-02	4.96634-02	4.96634-02	4.96634-02	4.96634-02	4.96634-02	4.96634-02	4.96634-02
18	4.99534-02	4.99534-02	4.99534-02	4.99534-02	4.99534-02	4.99534-02	4.99534-02	4.99534-02	4.99534-02	4.99534-02
19	5.01486-02	5.01486-02	5.01486-02	5.01486-02	5.01486-02	5.01486-02	5.01486-02	5.01486-02	5.01486-02	5.01486-02
20	5.02704-02	5.02704-02	5.02704-02	5.02704-02	5.02704-02	5.02704-02	5.02704-02	5.02704-02	5.02704-02	5.02704-02
21	5.03443-02	5.03443-02	5.03443-02	5.03443-02	5.03443-02	5.03443-02	5.03443-02	5.03443-02	5.03443-02	5.03443-02
22	5.03879-02	5.03879-02	5.03879-02	5.03879-02	5.03879-02	5.03879-02	5.03879-02	5.03879-02	5.03879-02	5.03879-02
23	5.04070-02	5.04070-02	5.04070-02	5.04070-02	5.04070-02	5.04070-02	5.04070-02	5.04070-02	5.04070-02	5.04070-02
24	5.04205-02	5.04205-02	5.04205-02	5.04205-02	5.04205-02	5.04205-02	5.04205-02	5.04205-02	5.04205-02	5.04205-02
25	5.04266-02	5.04266-02	5.04266-02	5.04266-02	5.04266-02	5.04266-02	5.04266-02	5.04266-02	5.04266-02	5.04266-02
26	5.04282-02	5.04282-02	5.04282-02	5.04282-02	5.04282-02	5.04282-02	5.04282-02	5.04282-02	5.04282-02	5.04282-02
27	5.04287-02	5.04287-02	5.04287-02	5.04287-02	5.04287-02	5.04287-02	5.04287-02	5.04287-02	5.04287-02	5.04287-02
28	5.04288-02	5.04288-02	5.04288-02	5.04288-02	5.04288-02	5.04288-02	5.04288-02	5.04288-02	5.04288-02	5.04288-02
29	5.18450-02	5.18450-02	5.18450-02	5.18450-02	5.18450-02	5.18450-02	5.18450-02	5.18450-02	5.18450-02	5.18450-02
30	5.44428-02	5.44428-02	5.44428-02	5.44428-02	5.44428-02	5.44428-02	5.44428-02	5.44428-02	5.44428-02	5.44428-02

ALBEDO(I),I=1,IX

```
 1.00000+00  1.00000+00  1.00000+00  1.00000+00  1.00000+00  1.00000+00  1.00000+00  1.00000+00  1.00000+00  1.00000+00
 1.00000+00  1.00000+00  1.00000+00  1.00000+00  1.00000+00  1.00000+00  1.00000+00  1.00000+00  1.00000+00  1.00000+00
 1.00000+00  1.00000+00  1.00000+00  1.00000+00  1.00000+00  1.00000+00  1.00000+00  1.00000+00  1.00000+00  1.00000+00
```

CYLINDRICAL GEOMETRY-WHITE BOUNDARY-CONSTANT ALBEDO
CYLINDRICAL CELL BOUNDARY

REGION	THICKNESS	POINT	VOLUME	R(CENTER)	R(INNER)	R(OUTER)
1	6.44500-01					
		1	7.72162-03	0.00000	0.00000	4.95769-02
		2	6.17730-02	9.91538-02	4.95769-02	1.48731-01
		3	1.23546-01	1.98308-01	1.48731-01	2.47885-01
		4	1.85319-01	2.97462-01	2.47885-01	3.47038-01
		5	2.47092-01	3.96615-01	3.47038-01	4.46192-01
		6	3.08865-01	4.95769-01	4.46192-01	5.45346-01
		7	3.70638-01	5.94923-01	5.45346-01	6.44500-01
2	7.62000-02					
		8	1.04884-01	6.57200-01	6.44500-01	6.69900-01
		9	1.08938-01	6.82600-01	6.69900-01	6.95300-01
		10	1.12992-01	7.08000-01	6.95300-01	7.20700-01
3	3.54000-01					
		11	1.64267-01	7.38403-01	7.20700-01	7.56106-01
		12	1.72143-01	7.73809-01	7.56106-01	7.91512-01
		13	1.80020-01	8.09215-01	7.91512-01	8.26918-01
		14	1.87896-01	8.44621-01	8.26918-01	8.62324-01
		15	1.95773-01	8.80027-01	8.62324-01	8.97730-01
		16	2.03649-01	9.15433-01	8.97730-01	9.33136-01
		17	2.11526-01	9.50839-01	9.33136-01	9.68542-01
		18	2.19402-01	9.86245-01	9.68542-01	1.00395+00
		19	2.27279-01	1.02165+00	1.00395+00	1.03935+00
		20	2.35155-01	1.05706+00	1.03935+00	1.07476+00

```
EARLIEST EXTRAP=101
NO. TESTED=  5
INCREMENT=  5
MAX ITS=100
CONV CRIT=  1.00000-05
OVERRELAXATION=  1.00000+00
EXTRAP CRIT=  5.00000-02
MAX EXTRAP=  1.00000+02
FACTOR=  1.00000+00
```

IT	RENORM	RMS RES	RATIO
1	1.20296	1.5877-02	.0000
2	.98156	1.2436-02	.7833
3	.98941	4.6876-03	.3769
4	.99709	2.0067-03	.4281
5	.99663	1.1114-03	.5538
6	.99803	6.4789-04	.5830
7	.99877	3.8770-04	.5984
8	.99915	2.4061-04	.6206
9	.99947	1.5037-04	.6249
10	.99964	9.5358-05	.6342
11	.99977	6.0859-05	.6382
12	.99985	3.9050-05	.6416
13	.99990	2.5164-05	.6444
14	.99994	1.6255-05	.6459
15	.99996	1.0524-05	.6474
16	.99997	6.8228-06	.6483
17	.99998	4.4286-06	.6491
18	.99999	2.8758-06	.6494
19	.99999	1.8696-06	.6501
20	1.00000	1.2151-06	.6499
21	1.00000	7.9019-07	.6503
22	1.00000	5.1454-07	.6512
23	1.00000	3.3397-07	.6491
24	1.00000	2.1761-07	.6516

THERMOS CASE NO. 1 PAGE 7

ITCNT= 24 REFCRV= 9.99999-01 EPS= 1.02222-05
LARGEST RES= 7.82311-06 MEAN RES= 2.17608-07 N(V*)= 2.71770-02

I	N(1,I)	N(2,I)	N(3,I)	N(4,I)	N(5,I)	N(6,I)	N(7,I)	N(8,I)	N(9,I)	N(10,I)
1	3.37153-04	4.21837-04	5.47130-04	6.28321-04	7.77227-04	1.33618-03	3.01687-03	7.82977-03	8.08720-03	8.33818-03
2	1.05612-02	1.11721-02	1.26397-02	1.47861-02	1.79786-02	2.43788-02	3.61156-02	5.47526-02	5.65383-02	5.81219-02
3	4.14547-02	4.27344-02	4.59832-02	5.09948-02	5.81806-02	7.11998-02	9.29109-02	1.22969-01	1.26647-01	1.30292-01
4	9.68049-02	9.87555-02	1.03880-01	1.11870-01	1.23179-01	1.42752-01	1.73936-01	2.14338-01	2.20476-01	2.25800-01
5	1.72575-01	1.75133-01	1.81914-01	1.92603-01	2.07608-01	2.32886-01	2.72184-01	3.21726-01	3.29570-01	3.36035-01
6	2.60836-01	2.63896-01	2.72036-01	2.84904-01	3.02904-01	3.32797-01	3.78509-01	4.35134-01	4.44148-01	4.52366-01
7	3.52546-01	3.55959-01	3.65024-01	3.79522-01	3.99728-01	4.32820-01	4.82882-01	5.43694-01	5.55361-01	5.63837-01
8	4.38494-01	4.42095-01	4.51791-01	4.67245-01	4.88722-01	5.23715-01	5.76158-01	6.40418-01	6.51911-01	6.62013-01
9	5.11115-01	5.14751-01	5.24620-01	5.40446-01	5.62481-01	5.98011-01	6.51195-01	7.14269-01	7.27801-01	7.38571-01
10	5.65463-01	5.69020-01	5.78781-01	5.94439-01	6.16203-01	6.51247-01	7.03394-01	7.65194-01	7.78843-01	7.89204-01
11	5.97441-01	6.00895-01	6.10278-01	6.25319-01	6.46312-01	6.79803-01	7.29615-01	7.88210-01	8.01844-01	8.12136-01
12	6.07341-01	6.10487-01	6.19300-01	6.33370-01	6.53002-01	6.84383-01	7.30929-01	7.85061-01	7.98441-01	8.08809-01
13	5.95962-01	5.98961-01	6.06981-01	6.19861-01	6.37841-01	6.66513-01	7.08966-01	7.58152-01	7.71025-01	7.80542-01
14	5.65916-01	5.68468-01	5.75641-01	5.87155-01	6.03203-01	6.28777-01	6.66630-01	7.09967-01	7.21255-01	7.30861-01
15	5.19633-01	5.22085-01	5.28335-01	5.38363-01	5.52381-01	5.74596-01	6.07439-01	6.45494-01	6.54994-01	6.63121-01
16	4.59871-01	4.61767-01	4.67035-01	4.75471-01	4.87319-01	5.06016-01	5.33615-01	5.65642-01	5.73730-01	5.80645-01
17	3.89736-01	3.91302-01	3.95583-01	4.02431-01	4.12024-01	4.27184-01	4.49548-01	4.75350-01	4.82068-01	4.87716-01
18	3.17461-01	3.18676-01	3.22061-01	3.27479-01	3.35063-01	3.47025-01	3.64706-01	3.84867-01	3.90423-01	3.94965-01
19	2.49513-01	2.50452-01	2.53084-01	2.57300-01	2.63198-01	2.72503-01	2.86281-01	3.01974-01	3.06273-01	3.09963-01
20	1.92071-01	1.92796-01	1.94845-01	1.98134-01	2.02740-01	2.10002-01	2.20773-01	2.33047-01	2.36449-01	2.39358-01
21	1.44856-01	1.45442-01	1.47073-01	1.49689-01	1.53368-01	1.59177-01	1.67784-01	1.77706-01	1.80386-01	1.82679-01
22	1.01559-01	1.02008-01	1.03284-01	1.05341-01	1.08229-01	1.12799-01	1.19593-01	1.27455-01	1.29500-01	1.31302-01
23	7.47056-02	7.51050-02	7.62206-02	7.80142-02	8.05494-02	8.45797-02	9.06122-02	9.76319-02	9.94912-02	1.01027-01
24	4.68158-02	4.71993-02	4.82574-02	4.99783-02	5.24209-02	5.63617-02	6.23913-02	6.96720-02	7.14162-02	7.29108-02
25	1.92663-02	1.96778-02	2.08014-02	2.26185-02	2.52952-02	2.98687-02	3.74648-02	4.75548-02	4.95479-02	5.12489-02
26	1.05344-02	1.08860-02	1.18176-02	1.33202-02	1.55880-02	1.96732-02	2.69122-02	3.73385-02	3.92434-02	4.07214-02
27	2.66961-02	2.68862-02	2.74171-02	2.82845-02	2.95233-02	3.15236-02	3.46207-02	3.83909-02	3.93307-02	4.01843-02
28	3.41867-02	3.42564-02	3.44495-02	3.47627-02	3.52037-02	3.58959-02	3.69231-02	3.80805-02	3.84396-02	3.87662-02
29	3.10625-02	3.10925-02	3.11761-02	3.13127-02	3.15046-02	3.18051-02	3.22501-02	3.27634-02	3.29165-02	3.30565-02
30	2.84213-02	2.84389-02	2.84676-02	2.85146-02	2.85825-02	2.86916-02	2.88636-02	2.91011-02	2.91569-02	2.91833-02

THERMOS CASE NO. 1 PAGE 8

ITCNT= 24 RENORM= 9.99999-01 EPS= 1.02222-05
LARGEST RES= 7.82311-06 MEAN RES= 2.17608-07 N(V*)= 2.71770-02

I	N(11,I)	N(12,I)	N(13,I)	N(14,I)	N(15,I)	N(16,I)	N(17,I)	N(18,I)	N(19,I)	N(20,I)
1	9.79840-03	1.17531-02	1.28623-02	1.36099-02	1.41449-02	1.45345-02	1.48095-02	1.49772-02	1.50337-02	1.49429-02
2	6.49979-02	7.56570-02	8.32646-02	8.88995-02	9.31142-02	9.62568-02	9.85141-02	9.99611-02	1.00703-01	1.00661-01
3	1.41869-01	1.60789-01	1.75175-01	1.86306-01	1.94907-01	2.01420-01	2.06161-01	2.09282-01	2.10862-01	2.10724-01
4	2.41945-01	2.68718-01	2.89774-01	3.06441-01	3.19546-01	3.29602-01	3.36970-01	3.41835-01	3.44240-01	3.43858-01
5	3.56537-01	3.89870-01	4.16594-01	4.38048-01	4.55080-01	4.68253-01	4.77935-01	4.84319-01	4.87427-01	4.86643-01
6	4.75789-01	5.13726-01	5.44576-01	5.69570-01	5.89548-01	6.05073-01	6.16489-01	6.23981-01	6.27439-01	6.26178-01
7	5.89073-01	6.29503-01	6.62665-01	6.89733-01	7.11419-01	7.28318-01	7.40732-01	7.48788-01	7.52368-01	7.50590-01
8	6.87260-01	7.28153-01	7.61809-01	7.89449-01	8.11612-01	8.28905-01	8.41552-01	8.49670-01	8.53088-01	8.50732-01
9	7.63332-01	8.02818-01	8.35541-01	8.62432-01	8.83976-01	9.00789-01	9.13028-01	9.20769-01	9.23776-01	9.20959-01
10	8.13306-01	8.50108-01	8.80592-01	9.05710-01	9.25826-01	9.41466-01	9.52773-01	9.59803-01	9.62272-01	9.59073-01
11	8.34623-01	8.67955-01	8.95458-01	9.18191-01	9.36325-01	9.50387-01	9.60472-01	9.66592-01	9.68477-01	9.65031-01
12	8.29031-01	8.58460-01	8.82757-01	9.02778-01	9.18725-01	9.31029-01	9.39778-01	9.44947-01	9.46279-01	9.42729-01
13	7.98627-01	8.24185-01	8.45197-01	8.62553-01	8.76272-01	8.86835-01	8.94256-01	8.98563-01	8.99413-01	8.95910-01
14	7.46613-01	7.68466-01	7.86499-01	8.01364-01	8.13100-01	8.22066-01	8.28352-01	8.31888-01	8.32423-01	8.29130-01
15	6.77011-01	6.95588-01	7.10954-01	7.23622-01	7.33602-01	7.41261-01	7.46562-01	7.49505-01	7.49864-01	7.46897-01
16	5.92112-01	6.07622-01	6.20463-01	6.31094-01	6.39470-01	6.45864-01	6.50310-01	6.52748-01	6.53024-01	6.50442-01
17	4.96888-01	5.09394-01	5.19715-01	5.28305-01	5.35068-01	5.40194-01	5.43796-01	5.45738-01	5.45922-01	5.43818-01
18	4.02142-01	4.11839-01	4.19824-01	4.26450-01	4.31633-01	4.35612-01	4.38310-01	4.39796-01	4.39883-01	4.38186-01
19	3.15512-01	3.22804-01	3.28782-01	3.33695-01	3.37546-01	3.40439-01	3.42441-01	3.43468-01	3.43464-01	3.42125-01
20	2.43681-01	2.49174-01	2.53638-01	2.57295-01	2.60128-01	2.62264-01	2.63695-01	2.64418-01	2.64367-01	2.63298-01
21	1.86171-01	1.90448-01	1.93881-01	1.96685-01	1.98833-01	2.00448-01	2.01522-01	2.02043-01	2.01964-01	2.01096-01
22	1.34092-01	1.37324-01	1.39879-01	1.41956-01	1.43534-01	1.44706-01	1.45477-01	1.45842-01	1.45755-01	1.45076-01
23	1.03468-01	1.06184-01	1.08304-01	1.10006-01	1.11296-01	1.12243-01	1.12852-01	1.13126-01	1.13024-01	1.12430-01
24	7.51964-02	7.76192-02	7.95170-02	8.10028-02	8.21113-02	8.29234-02	8.34280-02	8.36397-02	8.35190-02	8.29559-02
25	5.38487-02	5.63191-02	5.82362-02	5.96711-02	6.07264-02	6.15125-02	6.19737-02	6.21416-02	6.19717-02	6.13461-02
26	4.31168-02	4.52126-02	4.68511-02	4.80417-02	4.89053-02	4.95570-02	4.99125-02	5.00315-02	4.98679-02	4.93009-02
27	4.13925-02	4.25388-02	4.33759-02	4.39962-02	4.44515-02	4.47810-02	4.49699-02	4.50326-02	4.49575-02	4.46668-02
28	3.92487-02	3.96806-02	3.99848-02	4.02269-02	4.03988-02	4.05163-02	4.05909-02	4.06165-02	4.05859-02	4.04820-02
29	3.32645-02	3.34445-02	3.35752-02	3.36737-02	3.37447-02	3.37945-02	3.38239-02	3.38338-02	3.38208-02	3.37747-02
30	2.91790-02	2.91926-02	2.92101-02	2.92241-02	2.92357-02	2.92434-02	2.92475-02	2.92481-02	2.92436-02	2.92323-02

THE TABLE OF CURRENTS LISTED BELOW WAS CALCULATED USING THE T MATRIX CALCULATION.

I	J(1,I)	J(2,I)	J(3,I)	J(4,I)	J(5,I)	J(6,I)	J(7,I)	J(8,I)	J(9,I)	J(10,I)
1	-0.00000	-1.78651-05	-1.32028-04	-4.14768-04	-9.56075-04	-2.33671-03	-6.84591-03	-1.05861-02	-1.06655-02	-1.07512-02
2	-0.00000	-7.[illegible]0843-04	-3.25902-03	-8.19308-03	-1.66787-02	-3.13091-02	-5.78387-02	-7.60090-02	-7.61836-02	-7.63727-02
3	-0.00000	-2.17305-03	-9.07018-03	-2.17335-02	-4.18927-02	-7.30534-02	-1.22157-01	-1.53894-01	-1.54158-01	-1.54447-01
4	-0.00000	-3.93129-03	-1.61707-02	-3.79639-02	-7.13600-02	-1.20293-01	-1.92126-01	-2.37091-01	-2.37450-01	-2.37844-01
5	-0.00000	-5.[illegible]9293-03	-2.32417-02	-5.39734-02	-1.00064-01	-1.65554-01	-2.57775-01	-3.14382-01	-3.14829-01	-3.15305-01
6	-0.00000	-7.24576-03	-2.94525-02	-6.79490-02	-1.24909-01	-2.04303-01	-3.13194-01	-3.79176-01	-3.79685-01	-3.80223-01
7	-0.00000	-8.[illegible]5986-03	-3.42866-02	-7.87586-02	-1.43971-01	-2.33681-01	-3.54477-01	-4.26993-01	-4.27547-01	-4.28134-01
8	-0.00000	-9.27364-03	-3.75132-02	-8.59131-02	-1.56420-01	-2.52510-01	-3.80212-01	-4.56372-01	-4.56955-01	-4.57564-01
9	-0.00000	-9.[illegible]8167-03	-3.91053-02	-8.93580-02	-1.62225-01	-2.60847-01	-3.90660-01	-4.67688-01	-4.68255-01	-4.68861-01
10	-0.00000	-9.71286-03	-3.91882-02	-8.93990-02	-1.61934-01	-2.59593-01	-3.87167-01	-4.62607-01	-4.63165-01	-4.63749-01
11	-0.00000	-9.42277-03	-3.79889-02	-8.65530-02	-1.56519-01	-2.50336-01	-3.72197-01	-4.44013-01	-4.44542-01	-4.45097-01
12	-0.00000	-8.[illegible]8869-03	-3.58124-02	-8.15123-02	-1.47201-01	-2.35005-01	-3.48557-01	-4.15326-01	-4.15826-01	-4.16354-01
13	-0.00000	-8.17033-03	-3.29020-02	-7.48274-02	-1.34986-01	-2.15197-01	-3.18554-01	-3.79225-01	-3.79707-01	-3.80214-01
14	-0.00000	-7.32559-03	-2.94871-02	-6.70184-02	-1.20794-01	-1.92343-01	-2.84270-01	-3.38156-01	-3.38600-01	-3.39072-01
15	-0.00000	-6.[illegible]0694-03	-2.57804-02	-5.85627-02	-1.05481-01	-1.67796-01	-2.47651-01	-2.94403-01	-2.94796-01	-2.95206-01
16	-0.00000	-5.[illegible]2578-03	-2.18266-02	-4.95575-02	-8.92051-02	-1.41786-01	-2.09015-01	-2.48314-01	-2.48616-01	-2.48933-01
17	-0.00000	-4.41904-03	-1.77726-02	-4.03369-02	-7.25662-02	-1.15249-01	-1.69718-01	-2.01507-01	-2.01715-01	-2.01932-01
18	-0.00000	-3.49529-03	-1.40547-02	-3.18900-02	-5.73491-02	-9.10342-02	-1.33965-01	-1.58994-01	-1.59137-01	-1.59287-01
19	-0.00000	-2.71057-03	-1.08984-02	-2.47258-02	-4.44587-02	-7.05578-02	-1.03806-01	-1.23178-01	-1.23276-01	-1.23379-01
20	-0.00000	-2.10311-03	-8.45614-03	-1.91856-02	-3.44993-02	-5.47567-02	-8.05689-02	-9.56095-02	-9.56821-02	-9.57581-02
21	-0.00000	-1.[illegible]6385-03	-6.69172-03	-1.51880-02	-2.73249-02	-4.34010-02	-6.39215-02	-7.59052-02	-7.59957-02	-7.60902-02
22	-0.00000	-1.28184-03	-5.15758-03	-1.17151-02	-2.10989-02	-3.35591-02	-4.95185-02	-5.88585-02	-5.89352-02	-5.90151-02
23	-0.00000	-1.09510-03	-4.41088-03	-1.00353-02	-1.81138-02	-2.88989-02	-4.28187-02	-5.10050-02	-5.10870-02	-5.11725-02
24	-0.00000	-9.[illegible]0374-04	-3.96359-03	-9.07221-03	-1.65106-02	-2.66382-02	-4.00796-02	-4.80849-02	-4.81326-02	-4.81826-02
25	-0.00000	-8.42276-04	-3.46856-03	-8.16651-03	-1.54326-02	-2.62116-02	-4.23261-02	-5.24721-02	-5.24776-02	-5.24833-02
26	-0.00000	-[illegible]6117-04	-2.54190-03	-6.14458-03	-1.20094-02	-2.13447-02	-3.66700-02	-4.67322-02	-4.67496-02	-4.67696-02
27	-0.00000	-4.[illegible]6757-04	-2.00924-03	-4.60246-03	-8.38601-03	-1.35550-02	-2.04572-02	-2.45800-02	-2.46003-02	-2.46221-02
28	-0.00000	-2.06409-04	-8.28423-04	-1.87413-03	-3.35696-03	-5.30003-03	-7.74254-03	-9.16024-03	-9.17701-03	-9.19458-03
29	-0.00000	-9.27950-05	-3.72008-04	-8.40059-04	-1.50096-03	-2.36159-03	-3.43352-03	-4.04074-03	-4.02370-03	-4.00603-03
30	-0.00000	-3.06557-05	-1.22944-04	-2.77802-04	-4.96829-04	-7.82874-04	-1.14111-03	-1.27246-03	-1.11803-03	-9.57835-04

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THE TABLE OF CURRENTS LISTED BELOW WAS CALCULATED USING THE T MATRIX CALCULATION.

I	J(11,I)	J(12,I)	J(13,I)	J(14,I)	J(15,I)	J(16,I)	J(17,I)	J(18,I)	J(19,I)	J(20,I)
1	-6.43903-03	-5.94355-03	-3.55028-03	-2.76719-03	-2.28369-03	-1.92741-03	-1.62110-03	-1.31450-03	-9.40654-04	-3.65193-04
2	-6.82443-02	-5.37743-02	-4.29241-02	-3.43854-02	-2.73660-02	-2.13683-02	-1.60666-02	-1.12024-02	-6.60213-03	-2.18655-03
3	-1.42439-01	-1.19895-01	-1.00667-01	-8.38652-02	-6.88320-02	-5.50688-02	-4.21839-02	-2.98702-02	-1.78725-02	-5.98652-03
4	-2.22879-01	-1.93565-01	-1.66775-01	-1.41916-01	-1.18509-01	-9.61560-02	-7.45034-02	-5.32448-02	-3.20962-02	-1.08019-02
5	-2.96188-01	-2.63807-01	-2.30864-01	-1.99038-01	-1.68024-01	-1.37541-01	-1.07316-01	-7.70984-02	-4.66603-02	-1.57447-02
6	-3.61732-01	-3.23906-01	-2.86410-01	-2.49114-01	-2.11859-01	-1.74490-01	-1.36825-01	-9.86918-02	-5.98955-02	-2.02358-02
7	-4.09006-01	-3.69297-01	-3.28921-01	-2.87880-01	-2.46127-01	-2.03596-01	-1.60199-01	-1.15838-01	-7.04060-02	-2.38031-02
8	-4.33392-01	-3.98197-01	-3.56542-01	-3.13483-01	-2.69064-01	-2.23293-01	-1.76154-01	-1.27621-01	-7.76745-02	-2.62820-02
9	-4.50167-01	-4.10671-01	-3.69103-01	-3.25619-01	-2.80280-01	-2.33149-01	-1.84274-01	-1.33690-01	-8.14355-02	-2.75617-02
10	-4.45953-01	-4.08078-01	-3.67799-01	-3.25257-01	-2.80558-01	-2.33794-01	-1.85041-01	-1.34382-01	-8.19073-02	-2.77286-02
11	-4.20464-01	-3.92922-01	-3.54835-01	-3.14334-01	-2.71542-01	-2.26564-01	-1.79499-01	-1.30453-01	-7.95464-02	-2.69338-02
12	-4.01111-01	-3.68406-01	-3.33163-01	-2.95505-01	-2.55549-01	-2.13411-01	-1.69200-01	-1.23032-01	-7.50437-02	-2.54122-02
13	-3.66533-01	-3.37070-01	-3.05162-01	-2.70930-01	-2.34492-01	-1.95957-01	-1.55439-01	-1.13067-01	-6.89832-02	-2.33615-02
14	-3.27141-01	-3.01283-01	-2.73083-01	-2.42684-01	-2.10210-01	-1.75773-01	-1.39491-01	-1.01496-01	-6.19278-02	-2.09714-02
15	-2.85161-01	-2.63060-01	-2.38788-01	-2.12451-01	-1.84182-01	-1.54112-01	-1.22361-01	-8.90549-02	-5.43398-02	-1.84007-02
16	-2.40654-01	-2.22495-01	-2.02278-01	-1.80183-01	-1.56355-01	-1.30916-01	-1.03989-01	-7.57005-02	-4.61942-02	-1.56430-02
17	-1.95312-01	-1.80777-01	-1.64492-01	-1.46616-01	-1.27287-01	-1.06607-01	-8.46874-02	-6.16481-02	-3.76074-02	-1.27297-02
18	-1.539[illegible]-01	-1.42404-01	-1.29485-01	-1.15345-01	-1.00083-01	-8.37852-02	-6.65306-02	-4.84069-02	-2.95183-02	-9.98871-03
19	-1.19130-01	-1.09929-01	-9.97754-02	-8.87467-02	-7.69101-02	-6.43192-02	-5.10313-02	-3.71091-02	-2.26166-02	-7.65033-03
20	-9.23632-02	-8.50568-02	-7.70654-02	-6.84445-02	-5.92415-02	-4.94934-02	-3.92366-02	-2.85125-02	-1.73697-02	-5.87440-03
21	-7.33259-02	-6.73748-02	-6.09257-02	-5.40195-02	-4.66910-02	-3.89634-02	-3.08626-02	-2.24157-02	-1.36524-02	-4.61710-03
22	-5.67651-02	-5.19645-02	-4.68455-02	-4.14306-02	-3.57405-02	-2.97831-02	-2.35696-02	-1.71132-02	-1.04262-02	-3.52802-03
23	-4.91412-02	-4.48306-02	-4.03011-02	-3.55628-02	-3.06277-02	-2.54953-02	-2.01662-02	-1.46434-02	-8.92759-03	-3.02335-03
24	-4.61027-02	-4.17914-02	-3.73791-02	-3.28594-02	-2.82239-02	-2.34582-02	-1.85485-02	-1.34812-02	-8.23809-03	-2.79672-03
25	-5.00280-02	-4.50660-02	-4.01190-02	-3.51505-02	-3.01252-02	-2.50147-02	-1.97890-02	-1.44114-02	-8.83825-03	-3.01097-03
26	-4.48925-02	-3.99130-02	-3.54214-02	-3.09700-02	-2.65089-02	-2.20046-02	-1.74191-02	-1.27056-02	-7.81380-03	-2.66927-03
27	-2.34023-02	-2.09517-02	-1.85673-02	-1.62145-02	-1.38671-02	-1.15045-02	-9.10435-03	-6.64077-03	-4.08570-03	-1.39665-03
28	-8.74302-03	-7.82650-03	-6.93414-03	-6.05389-03	-5.17724-03	-4.29448-03	-3.39756-03	-2.47791-03	-1.52410-03	-5.20718-04
29	-3.79319-03	-3.38915-03	-2.99874-03	-2.61582-03	-2.23571-03	-1.85422-03	-1.46738-03	-1.07088-03	-6.59520-04	-2.25649-04
30	-8.35090-04	-7.52561-04	-6.69503-04	-5.86369-04	-5.02785-04	-4.18213-04	-3.31855-04	-2.42835-04	-1.49961-04	-5.14072-05

THERMOS CASE NO. 1 PAGE 11
AVERAGES FOR I= 6 TO I=30 V= 0.00000 TO V= 5.19579+00
E= 0.00000 TO E= 6.83005-01

POINT	REG	MIX	ENERGY	NDEN*VOL	NFLUX*VOL	ABSORPTION	SCATTERING	FISSIONS	NBAR(I)	MID ENERGY
7	1	1	5.70609-04	2.90535-04	2.18046-05	1.57577-04	1.86163-05	1.09056-04	1.48328-03	1.42502-04
7	1	1	1.57999-03	3.03705-03	6.07409-04	1.64531-03	2.75701-04	1.13860-03	2.33198-02	1.01200-03
7	1	1	3.09996-03	8.90191-03	2.67031-03	4.83687-03	1.04742-03	3.33612-03	6.81209-02	2.27654-03
7	1	1	5.12601-03	1.79076-02	7.16216-03	9.74702-03	2.63325-03	6.71362-03	1.37482-01	4.04699-03
7	1	1	7.65005-03	2.94518-02	1.47220-02	1.60489-02	5.23817-03	1.10370-02	2.25624-01	6.32171-03
7	1	1	1.06899-02	4.23239-02	2.53922-02	2.31402-02	8.96919-03	1.58565-02	3.23879-01	9.10648-03
7	1	1	1.42297-02	5.51237-02	3.85860-02	3.02440-02	1.33259-02	2.06343-02	4.22672-01	1.23966-02
7	1	1	1.82799-02	6.69499-02	5.35592-02	3.69012-02	1.93604-02	2.50794-02	5.12788-01	1.61916-02
7	1	1	2.28296-02	7.65071-02	6.88541-02	4.24162-02	2.34832-02	2.87032-02	5.86810-01	2.04916-02
7	1	1	2.80017-02	8.52668-02	8.53521-02	4.76110-02	2.90022-02	3.20018-02	6.40094-01	2.53506-02
7	1	1	3.34595-02	8.55727-02	9.42156-02	4.81860-02	3.19270-02	3.22341-02	6.69067-01	3.06687-02
7	1	1	3.95303-02	8.79668-02	1.05560-01	5.00145-02	3.56979-02	3.32886-02	6.74301-01	3.64320-02
7	1	1	4.61103-02	8.57958-02	1.11535-01	4.93913-02	3.76571-02	3.26501-02	6.57265-01	4.27570-02
7	1	1	5.31909-02	8.09221-02	1.13291-01	4.72792-02	3.82009-02	3.09821-02	6.20517-01	4.95880-02
7	1	1	6.07838-02	7.40483-02	1.11072-01	4.40951-02	3.74139-02	2.86582-02	5.67383-01	5.69250-02
7	1	1	6.97200-02	7.18130-02	1.15260-01	4.38664-02	3.87897-02	2.83229-02	4.99918-01	6.51734-02
7	1	1	8.01583-02	6.60926-02	1.13679-01	4.16881-02	3.82274-02	2.66323-02	4.22238-01	7.48475-02
7	1	1	9.22904-02	5.82227-02	1.07421-01	3.83276-02	3.60975-02	2.42604-02	3.43126-01	8.61218-02
7	1	1	1.06320-01	4.92106-02	9.74370-02	3.43105-02	3.27224-02	2.14484-02	2.69477-01	9.91861-02
7	1	1	1.21900-01	3.93093-02	8.34339-02	2.94696-02	2.80050-02	1.82486-02	2.07645-01	1.13977-01
7	1	1	1.40908-01	3.38598-02	7.71157-02	2.81900-02	2.58723-02	1.72246-02	1.57293-01	1.31231-01
7	1	1	1.64512-01	2.75994-02	6.77566-02	2.71725-02	2.27226-02	1.63848-02	1.11326-01	1.52484-01
7	1	1	1.79993-01	1.27561-02	3.32757-02	1.53133-02	1.11558-02	9.18321-03	8.32992-02	1.72161-01
7	1	1	2.31516-01	2.57474-02	7.32824-02	4.81062-02	2.45591-02	2.87199-02	5.51641-02	2.04952-01
7	1	1	2.78069-01	1.10599-02	3.50876-02	4.94198-02	1.17544-02	2.90230-02	2.87270-02	2.54638-01
7	1	1	3.38907-01	8.35842-03	2.91709-02	5.78493-02	9.76959-03	3.43201-02	1.88398-02	3.08157-01
7	1	1	4.14991-01	1.57393-02	6.06749-02	3.85646-02	2.03158-02	2.32749-02	3.09277-02	3.75984-01
7	1	1	5.11195-01	2.07134-02	8.84979-02	1.78186-02	2.96258-02	1.09207-02	3.56710-02	4.61833-01
7	1	1	6.32504-01	2.08962-02	9.92048-02	1.04672-02	3.32046-02	5.92509-03	3.17070-02	5.70231-01
7	1	1	6.83005-01	7.32215-03	3.73276-02	3.05353-03	1.24927-02	1.57616-03	2.86599-02	6.57511-01
SUM	VOLUME=		1.30495+00	1.26877+00	1.95123+00	9.35332-01	6.58465-01	5.97888-01		
AVE.				9.72269-01	1.49524+00	7.16754-01	5.04589-01	4.58167-01		

THERMOS CASE NO. 1 PAGE 12
AVERAGES FOR I= 6 TO I=30 V= 0.00000 TO V= 5.19579+00
E= 0.00000 TO E= 6.83005-01

POINT	REG	MIX	ENERGY	NDEN*VOL	NFLUX*VOL	ABSCRPTION	SCATTERING	FISSIONS	NBAR(I)	MID ENERGY
10	2	2	5.70009-04	3.96920-04	2.97888-05	3.20198-06	1.44274-05	0.00000	8.09136-03	1.42502-04
10	2	2	1.57999-03	1.84322-03	3.68644-04	1.48694-05	1.10806-04	0.00000	5.65128-02	1.01200-03
10	2	2	3.09996-03	4.14741-03	1.24410-03	3.34575-05	3.48917-04	0.00000	1.26727-01	2.27654-03
10	2	2	5.12001-03	7.18792-03	2.87481-03	5.79855-05	7.85977-04	0.00000	2.20347-01	4.04699-03
10	2	2	7.65005-03	1.07648-02	5.38101-03	8.68406-05	1.45360-03	0.00000	3.29288-01	6.32171-03
10	2	2	1.06899-02	1.45340-02	8.71968-03	1.17247-04	2.34001-03	0.00000	4.44096-01	9.10648-03
10	2	2	1.42297-02	1.81125-02	1.26786-02	1.46115-04	3.38884-03	0.00000	5.54547-01	1.23966-02
10	2	2	1.82799-02	2.13096-02	1.70475-02	1.71906-04	4.54476-03	0.00000	6.51715-01	1.61916-02
10	2	2	2.28296-02	2.37439-02	2.13688-02	1.91544-04	5.68663-03	0.00000	7.27182-01	2.04916-02
10	2	2	2.80017-02	2.59565-02	2.59824-02	2.09393-04	6.90547-03	0.00000	7.78045-01	2.53506-02
10	2	2	3.34595-02	2.56577-02	2.82492-02	2.06983-04	7.50081-03	0.00000	8.01027-01	3.06687-02
10	2	2	3.95303-02	2.60632-02	3.12758-02	2.10254-04	8.29853-03	0.00000	7.97732-01	3.64320-02
10	2	2	4.61103-02	2.51782-02	3.27317-02	2.03115-04	8.67995-03	0.00000	7.70184-01	4.27570-02
10	2	2	5.31909-02	2.35465-02	3.29650-02	1.89951-04	8.73792-03	0.00000	7.20953-01	4.95880-02
10	2	2	6.07836-02	2.14005-02	3.21007-02	1.72639-04	8.50575-03	0.00000	6.54755-01	5.69250-02
10	2	2	6.97200-02	2.06330-02	3.31159-02	1.66448-04	8.77204-03	0.00000	5.73525-01	6.51734-02
10	2	2	8.01583-02	1.88897-02	3.24903-02	1.52385-04	8.60397-03	0.00000	4.81865-01	7.48475-02
10	2	2	9.22984-02	1.65822-02	3.05942-02	1.33770-04	8.09989-03	0.00000	3.90210-01	8.61218-02
10	2	2	1.06320-01	1.40024-02	2.77248-02	1.12959-04	7.33865-03	0.00000	3.06169-01	9.91861-02
10	2	2	1.21900-01	1.12062-02	2.37851-02	9.04011-05	6.29468-03	0.00000	2.36363-01	1.13977-01
10	2	2	1.40908-01	9.72121-03	2.21401-02	7.84218-05	5.85838-03	0.00000	1.80319-01	1.31231-01
10	2	2	1.64512-01	8.03835-03	1.97341-02	6.48460-05	5.22099-03	0.00000	1.29467-01	1.52484-01
10	2	2	1.79993-01	3.81312-03	9.94691-03	3.07608-05	2.63135-03	0.00000	9.94253-02	1.72161-01
10	2	2	2.31516-01	8.34292-03	2.37456-02	6.73030-05	6.28083-03	0.00000	7.13732-02	2.04952-01
10	2	2	2.78869-01	4.77244-03	1.51406-02	3.84996-05	4.00422-03	0.00000	4.94964-02	2.54638-01
10	2	2	3.38907-01	4.34919-03	1.51787-02	3.50853-05	4.01392-03	0.00000	3.91430-02	3.08157-01
10	2	2	4.14981-01	5.01190-03	1.93209-02	4.04314-05	5.10889-03	0.00000	3.93242-02	3.75984-01
10	2	2	5.11185-01	5.58977-03	2.38823-02	4.50931-05	6.31460-03	0.00000	3.84373-02	4.61833-01
10	2	2	6.32504-01	5.43278-03	2.57921-02	4.38266-05	6.81917-03	0.00000	3.29158-02	5.70231-01
10	2	2	6.83005-01	1.86500-03	9.50760-03	1.50451-05	2.51363-03	0.00000	2.91481-02	6.57511-01
SUM	VOLUME=		3.26814-01	3.88093-01	5.85117-01	3.13078-03	1.55178-01	0.00000		
AVE.				1.18750+00	1.79037+00	9.57969-03	4.74819-01	0.00000		

THERMOS CASE NO. 1 PAGE 13
AVERAGES FOR I= 0 TO I=30 V= 0.00000 TO V= 5.19579+00
E= 0.00000 TO E= 6.83005-01

POINT	REG	MIX	ENERGY	NDEN*VOL	NFLUX*VOL	ABSORPTION	SCATTERING	FISSIONS	NBAR(I)	MID ENERGY
20	3	3	1.76009-04	4.14036-03	3.10734-04	9.17581-05	6.18262-03	0.00000	1.38120-02	1.42502-04
20	3	3	1.57999-03	1.82189-02	3.64379-03	4.03766-04	3.11465-02	0.00000	9.14094-02	1.01200-03
20	3	3	3.69996-03	3.84240-02	1.15261-02	8.51549-04	7.59018-02	0.00000	1.92129-01	2.27654-03
20	3	3	5.12001-03	6.29636-02	2.51823-02	1.39539-03	1.43046-01	0.00000	3.15858-01	4.04699-03
20	3	3	7.65005-03	9.00288-02	4.50027-02	1.99521-03	2.30992-01	0.00000	4.50660-01	6.32171-03
20	3	3	1.08899-02	1.16908-01	7.01389-02	2.59090-03	3.81567-01	0.00000	5.84567-01	9.10648-03
20	3	3	1.42297-02	1.40924-01	9.86457-02	3.12315-03	4.32731-01	0.00000	7.06066-01	1.23966-02
20	3	3	1.82799-02	1.61051-01	1.28845-01	3.56935-03	5.35663-01	0.00000	8.06052-01	1.61916-02
20	3	3	2.26296-02	1.75265-01	1.57733-01	3.88420-03	5.98349-01	0.00000	8.78382-01	2.04916-02
20	3	3	2.80017-02	1.87621-01	1.87808-01	4.15803-03	6.61126-01	0.00000	9.20319-01	2.53506-02
20	3	3	3.34505-02	1.82237-01	2.00643-01	4.03872-03	6.54791-01	0.00000	9.31032-01	3.06687-02
20	3	3	3.95303-02	1.82429-01	2.18915-01	4.04297-03	6.62838-01	0.00000	9.13738-01	3.64320-02
20	3	3	4.61103-02	1.74136-01	2.26377-01	3.85919-03	6.37534-01	0.00000	8.71681-01	4.27570-02
20	3	3	5.31999-02	1.61454-01	2.26035-01	3.57812-03	5.98544-01	0.00000	8.08962-01	4.95880-02
20	3	3	6.07836-02	1.45805-01	2.18708-01	3.23132-03	5.55259-01	0.00000	7.30007-01	5.69250-02
20	3	3	6.97200-02	1.39912-01	2.24559-01	3.10072-03	5.58240-01	0.00000	6.36422-01	6.51734-02
20	3	3	8.01583-02	1.27581-01	2.19440-01	2.82744-03	5.39849-01	0.00000	5.32579-01	7.48475-02
20	3	3	9.22984-02	1.11578-01	2.05862-01	2.47279-03	4.97240-01	0.00000	4.29669-01	8.61218-02
20	3	3	1.06320-01	9.39003-02	1.85923-01	2.08101-03	4.33349-01	0.00000	3.35987-01	9.91861-02
20	3	3	1.21900-01	7.50093-02	1.59207-01	1.66235-03	3.54400-01	0.00000	2.58902-01	1.13977-01
20	3	3	1.40966-01	6.51788-02	1.48445-01	1.44448-03	3.20981-01	0.00000	1.97845-01	1.31231-01
20	3	3	1.64512-01	5.41637-02	1.32972-01	1.20037-03	2.82856-01	0.00000	1.42757-01	1.52484-01
20	3	3	1.79993-01	2.59234-02	6.76237-02	5.74511-04	1.32801-01	0.00000	1.10613-01	1.72161-01
20	3	3	2.31516-01	5.81924-02	1.65627-01	1.28965-03	3.26109-01	0.00000	8.14670-02	2.04952-01
20	3	3	2.73869-01	3.53757-02	1.12229-01	7.83993-04	2.11780-01	0.00000	6.00395-02	2.54638-01
20	3	3	3.38907-01	3.27929-02	1.14447-01	7.26752-04	2.06516-01	0.00000	4.82975-02	3.08157-01
20	3	3	4.14981-01	3.43703-02	1.32497-01	7.61711-04	2.30664-01	0.00000	4.41305-02	3.75984-01
20	3	3	5.11135-01	3.57924-02	1.52923-01	7.93227-04	2.57287-01	0.00000	4.02761-02	4.61833-01
20	3	3	6.32504-01	3.39826-02	1.61332-01	7.53118-04	2.62794-01	0.00000	3.36928-02	5.70231-01
20	3	3	6.83005-01	1.14279-02	5.82583-02	2.53264-04	9.05422-02	0.00000	2.92278-02	6.57511-01
SUM	VOLUME=		1.99711+00	2.77679+00	4.06086+00	6.15390-02	1.08511+01	0.00000		
AVE.				1.39041+00	2.03337+00	3.08140-02	5.43339+00	0.00000		

THERMOS CASE NO. 1 PAGE 13
AVERAGES FOR I= 0 TO I=30 V= 0.00000 TO V= 5.19579+00
E= 0.00000 TO E= 6.83005-01

POINT	REG	MIX	VOLUME	NDEN*VOL	NFLUX*VOL	ABSORPTION	SCATTERING	FISSIONS	AVE V	AVE V**2	AVE V**3	NFLUX
1	1	1	7.7216-03	6.6399-03	1.0363-02	4.7422-03	3.4956-03	3.0364-03	1.56068	3.23971	8.91828	9.9425-02
2	1	1	6.1773-02	5.3448-02	8.3344-02	3.8229-02	2.8115-02	2.4476-02	1.55934	3.23529	8.90133	9.9955-02
3	1	1	1.2355-01	1.0869-01	1.6912-01	7.8042-02	5.7053-02	4.9956-02	1.55599	3.22403	8.85750	1.0141-01
4	1	1	1.8532-01	1.6732-01	2.5953-01	1.2087-01	8.7560-02	7.7350-02	1.55107	3.20745	8.79247	1.0375-01
5	1	1	2.4709-01	2.3113-01	3.5705-01	1.6842-01	1.2048-01	1.0773-01	1.54479	3.18667	8.71084	1.0705-01
6	1	1	3.0886-01	3.0529-01	4.6863-01	2.2562-01	1.5815-01	1.4421-01	1.53504	3.15561	8.59132	1.1241-01
7	1	1	3.7064-01	3.9624-01	6.0319-01	2.9940-01	2.0362-01	1.9113-01	1.52227	3.11749	8.44721	1.2057-01
SUM	1	1	1.3050+00	1.2688+00	1.9512+00	9.3533-01	6.5847-01	5.9789-01				
V AVE	1	1		N= 9.7227-01	P= 1.4952+00	A= 7.1675-01	S= 5.0459-01	F= 4.5817-01	1.53789	3.16586	8.63219	
8	2	2	1.0488-01	1.2243-01	1.8467-01	9.8762-04	4.8975-02	0.0000	1.50839	3.08005	8.31252	1.3044-01
9	2	2	1.0894-01	1.2945-01	1.9516-01	1.0443-03	5.1757-02	0.0000	1.50760	3.07742	8.29789	1.3272-01
10	2	2	1.1299-01	1.3622-01	2.0529-01	1.0989-03	5.4446-02	0.0000	1.50710	3.07609	8.28924	1.3460-01
SUM	2	2	3.2681-01	3.8809-01	5.8512-01	3.1308-03	1.5518-01	0.0000				
V AVE	2	2		N= 1.1875+00	P= 1.7904+00	A= 9.5797-03	S= 4.7482-01	F= 0.0000	1.50767	3.07778	8.29947	
11	3	3	1.6427-01	2.0400-01	3.0605-01	4.5211-03	8.0699-01	0.0000	1.50024	3.05464	8.21423	1.3803-01
12	3	3	1.7214-01	2.2285-01	3.3124-01	4.9388-03	8.7757-01	0.0000	1.48640	3.00834	8.05338	1.4256-01
13	3	3	1.8002-01	2.4073-01	3.5530-01	5.3350-03	9.4477-01	0.0000	1.47596	2.97263	7.92796	1.4622-01
14	3	3	1.8790-01	2.5777-01	3.7837-01	5.7126-03	1.0090+00	0.0000	1.46789	2.94452	7.82845	1.4919-01
15	3	3	1.9577-01	2.7392-01	4.0037-01	6.0707-03	1.0701+00	0.0000	1.46160	2.92243	7.75013	1.5151-01
16	3	3	2.0365-01	2.8923-01	4.2135-01	6.4098-03	1.1282+00	0.0000	1.45681	2.90553	7.69022	1.5328-01
17	3	3	2.1153-01	3.0358-01	4.4115-01	6.7278-03	1.1828+00	0.0000	1.45317	2.89263	7.64480	1.5451-01
18	3	3	2.1940-01	3.1685-01	4.5962-01	7.0221-03	1.2335+00	0.0000	1.45057	2.88348	7.61309	1.5520-01
19	3	3	2.2728-01	3.2884-01	4.7646-01	7.2878-03	1.2795+00	0.0000	1.44889	2.87769	7.59402	1.5531-01
20	3	3	2.3516-01	3.3902-01	4.9095-01	7.5134-03	1.3187+00	0.0000	1.44812	2.87532	7.58815	1.5467-01
SUM	3	3	1.9971+00	2.7768+00	4.0609+00	6.1539-02	1.0851+01	0.0000				
V AVE	3	3		N= 1.3904+00	P= 2.0334+00	A= 3.0814-02	S= 5.4334+00	F= 0.0000	1.46243	2.92493	7.75959	

THERMOS CASE NO. 1 PAGE 14
AVERAGES FOR I= 0 TO I=30 V= 0.00000 TO V= 5.19579+00
E= [illegible] TO E= 6.83005-01

MATERIALS USED IN CELL

MICROSCOPIC CONSTANTS FOR ISOTOPE H 1 11-15-66 NUMBER 1001. 1029.

REG	MIX	DENSITY	PARTIAL DENSITY	SIGMA A	SIGMA F	NU*SIGMA F	SIGMA S	SIGMA S1	SIGMA TR	D
1	1	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	0.00[illegible]	0.0000	0.0000
2	2	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	3	[illegible]735-02	3.6727-02	2.2702-01	0.0000	0.0000	3.8122+01	9.9538+00	2.9854+01	1.1166-02
REG. SMEAR VALUES			4.1078-02	2.2702-01	0.0000	0.0000	3.8122+01	9.9538+00	2.9854+01	1.1166-02
CELL SMEAR VALUES			3.6727-02	2.5392-01	0.0000	0.0000	4.26[illegible]9+01	9.3364+00	2.8002+01	1.1904-02

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MICROSCOPIC CONSTANTS FOR ISOTOPE O 16 11-15-66 NUMBER 8000. 29.

REG	MIX	DENSITY	PARTIAL DENSITY	SIGMA A	SIGMA F	NU*SIGMA F	SIGMA S	SIGMA S1	SIGMA TR	D
1	1	4.2162-02	1.5162-02	1.1574-04	0.0000	0.0000	3.82[illegible]0+00	1.6045-01	3.6903+00	9.0327-02
2	3	[illegible]	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	3	3.3367-02	1.8363-02	1.2172-04	0.0000	0.0000	3.83[illegible]7+00	1.6035-01	3.6880+00	9.0382-02
REG. SMEAR VALUES			3.3009-02	1.1946-04	0.0000	0.0000	3.83[illegible]7+00	1.6040-01	3.6890+00	9.0358-02
CELL SMEAR VALUES			3.3525-02	1.1762-04	0.0000	0.0000	3.77[illegible]7+00	1.4595-01	3.3566+00	9.9306-02

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THERMOS CASE NO. 1 PAGE 15
AVERAGES FOR I= 0 TO I=30 V= 0.00000 TO V= 5.19579+00
E= 0.00000 TO E= 6.83005-01

MATERIALS USED IN CELL

MICROSCOPIC CONSTANTS FOR ISOTOPE U 235 4- 3-68 NUMBER 92235. 29.

REG	MIX	DENSITY	PARTIAL DENSITY	SIGMA A	SIGMA F	NU*SIGMA F	SIGMA S	SIGMA S1	SIGMA TR	D
1	1	1.5065-04	5.4175-05	4.1581+02	3.5394+02	8.6006+02	1.0012+01	2.8412-02	4.9633+02	6.7159-04
2	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REG. SMEAR VALUES			4.4558-05	4.1581+02	3.5394+02	8.6006+02	1.0012+01	2.8412-02	4.9633+02	6.7159-04
CELL SMEAR VALUES			5.4175-05	3.4200+02	2.9111+02	7.0739+02	8.2347+00	2.4887-02	4.3474+02	7.6674-04

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MICROSCOPIC CONSTANTS FOR ISOTOPE U 238 4- 3-68 NUMBER 92238. 29.

REG	MIX	DENSITY	PARTIAL DENSITY	SIGMA A	SIGMA F	NU*SIGMA F	SIGMA S	SIGMA S1	SIGMA TR	D
1	1	2.0511-02	7.3760-03	1.7882+00	0.0000	0.0000	8.3098+00	2.3285-02	1.0307+01	3.2342-02
2	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REG. SMEAR VALUES			6.0666-03	1.7882+00	0.0000	0.0000	8.3098+00	2.3285-02	1.0307+01	3.2342-02
CELL SMEAR VALUES			7.3760-03	1.4708+00	0.0000	0.0000	6.8347+00	2.0395-02	9.0276+00	3.6924-02

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AVERAGES FOR I= 0 TO I=30 V= 0.00000 TO V= 5.19579+00
E= 0.00000 TO E= 6.83005-01

MATERIALS USED IN CELL

MICROSCOPIC CONSTANTS FOR ISOTOPE PU 239 4- 3-68 NUMBER 94239. 29,

REG	MIX	DENSITY	PARTIAL DENSITY	SIGMA A	SIGMA F	NU*SIGMA F	SIGMA S	SIGMA S1	SIGMA TR	D
1	1	3.[illegible]95-04	1.3807-04	9.6349+02	6.5349+02	1.8762+03	1.0012+01	2.7934-02	1.3397+03	2.4881-04
2	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REG. SMEAR VALUES			1.1356-04	9.6349+02	6.5349+02	1.8762+03	1.0012+01	2.7934-02	1.3397+03	2.4881-04
CELL SMEAR VALUES			1.3807-04	7.9245+02	5.3748+02	1.5431+03	8.2345+00	2.4467-02	1.1734+03	2.8407-04

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MICROSCOPIC CONSTANTS FOR ISOTOPE PU 240 4- 3-68 NUMBER 94240. 29,

REG	MIX	DENSITY	PARTIAL DENSITY	SIGMA A	SIGMA F	NU*SIGMA F	SIGMA S	SIGMA S1	SIGMA TR	D
1	1	3.1925-05	1.1480-05	2.2102+02	4.1861-02	1.0478-01	1.0012+01	2.7817-02	2.4137+02	1.3810-03
2	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REG. SMEAR VALUES			9.4424-06	2.2102+02	4.1861-02	1.0478-01	1.0012+01	2.7817-02	2.4137+02	1.3810-03
CELL SMEAR VALUES			1.1480-05	1.8179+02	3.4430-02	8.6173-02	8.2345+00	2.4365-02	2.1142+02	1.5767-03

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THERMOS CASE NO. 1 PAGE 17
AVERAGES FOR I= 0 TO I=30 V= 0.00000 TO V= 5.19579+00
E= 0.00000 TO E= 6.83005-01

MATERIALS USED IN CELL

MICROSCOPIC CONSTANTS FOR ISOTOPE PU 241 4- 3-68 NUMBER 94241. 29,

REG	MIX	DENSITY	PARTIAL DENSITY	SIGMA A	SIGMA F	NU*SIGMA F	SIGMA S	SIGMA S1	SIGMA TR	D
1	1	2.9092-06	1.0461-06	1.0441+03	7.5041+02	2.2280+03	1.0012+01	2.7702-02	1.2933+03	2.5775-04
2	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REG. SMEAR VALUES			8.6043-07	1.0441+03	7.5041+02	2.2280+03	1.0012+01	2.7702-02	1.2933+03	2.5775-04
CELL SMEAR VALUES			1.0461-06	8.5876+02	6.1720+02	1.8325+03	8.2344+00	2.4264-02	1.1328+03	2.9426-04

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MICROSCOPIC CONSTANTS FOR ISOTOPE PU 242 7-17-69 NUMBER 94242. 29,

REG	MIX	DENSITY	PARTIAL DENSITY	SIGMA A	SIGMA F	NU*SIGMA F	SIGMA S	SIGMA S1	SIGMA TR	D
1	1	1.2416-07	4.4649-08	1.3604+01	1.0746-02	3.0176-02	1.0012+01	2.7587-02	2.5163+01	1.3247-02
2	2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REG. SMEAR VALUES			3.6723-08	1.3604+01	1.0746-02	3.0176-02	1.0012+01	2.7587-02	2.5163+01	1.3247-02
CELL SMEAR VALUES			4.4649-08	1.1189+01	8.8386-03	2.4819-02	8.2344+00	2.4164-02	2.2041+01	1.5124-02

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THERMOS CASE NO. 1 PAGE 18
AVERAGES FOR I= 0 TO I=30 V= 0.00000 TO V= 5.19579+00
E= 0.00000 TO E= 6.83005-01

MATERIALS USED IN CELL

MICROSCOPIC CONSTANTS FOR ISOTOPE ZR 11-15-66 NUMBER 40000. 29,
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REG	MIX	DENSITY	PARTIAL DENSITY	SIGMA A	SIGMA F	NU*SIGMA F	SIGMA S	SIGMA S1	SIGMA TR	D
1	1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	2	4.2910-02	3.8644-03	1.2470-01	0.0000	0.0000	6.1806+00	4.5219-02	6.2809+00	5.3071-02
3	3	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
REC. SMEAR VALUES			3.8058-03	1.2470-01	0.0000	0.0000	6.1806+00	4.5219-02	6.2809+00	5.3071-02
C_LL SMEAR VALUES			3.8644-03	1.2280-01	0.0000	0.0000	6.0867+00	8.4767-02	1.1774+01	2.8311-02

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THERMOS CASE NO. 1 PAGE 19
AVERAGES FOR I= 8 TO I=30 V= 0.00000 TO V= 5.19579+00
E= 0.00000 TO E= 6.83005-01

MACROSCOPIC CELL VALUES

REG	RADIUS	VOLUME FRACTION	FLUX DEPRESSION	CURRENT DEPRESSION	INVERSE VELOCITY	D*CURRENT
1	6.4449998-01	3.5960267-01	8.2247991-01	8.7590353-01	6.5024072-01	3.4448785-01
2	7.2069997-01	9.0059245-02	9.8481599-01	1.8745988+00	6.6327446-01	1.2367978+00
3	1.0747599+00	5.5033810-01	1.1184816+00	9.3796629-01	6.8379502-01	1.5757871-01
CELL SMEAR VALUES		1.0000000+00	1.0000000+00	1.0000000+00	6.7205132-01	2.3112565-01

REG	SIGMA A	SIGMA F	NU*SIGMA F	SIGMA S	SIGMA S1	D*FLUX
1	4.7935585-01	3.0641638-01	8.5642007-01	3.3746246-01	7.2586385-03	4.5009189-01
2	5.3506873-03	0.0000000	0.0000000	2.6520782-01	1.9403359-03	1.2412976+00
3	1.5154183-02	0.0000000	0.0000000	2.6721139+00	6.6961847-01	2.0085366-01
CELL SMEAR	1.5157976-01	9.0627541-02	2.5329992-01	1.7681327+00	3.4826999-01	3.6684883-01

TIME SURVEY

SECTION	TIME (SEC.)
PROB. SETUP...	2
TRANS. CALC...	21
FLUX CALC.....	11
CROSS. EDIT...	3
TOTAL...............	37

END OF SAMPLE CASE

APPENDIX B

LIST OF LIBRARY MATERIALS

APPENDIX B

LIST OF LIBRARY MATERIALS

THERMS/UR9069
Random Access Library

Isotope/ Element		Date	First Ident	Second Ident	Number of Kernels
BE	9	11-15-66	4009.	1029.	1
C	12	11-15-66	6012.	29.	1
C	12	11-15-66	6012.	1010.	1
C	12	11-15-66	6012.	1029.	1
C	12	10-21-68	6012.	1042.	1
C	12	10-21-68	6012.	1057.	1
C	12	11-15-66	6012.	1069.	1
C	12	11-15-66	6012.	1097.	1
C	12	11-15-66	6012.	1127.	1
C	12	11-15-66	6012.	1150.	1
C	12	11-15-66	6012.	1200.	1
B		11-15-66	5000.	0.	0
B	10	11-15-66	5010.	0.	0
NA		11-15-66	11000.	29.	1
K		11-15-66	19000.	29.	1
CO		11-15-66	27000.	29.	1
AL	27	11-15-66	13000.	29.	1
NI		11-15-66	28000.	29.	1
CU		11-15-66	29000.	0	0
CU	63	11-15-66	29063.	0.	0
CU	65	11-15-66	29065.	0.	0
ZR		11-15-66	40000.	29.	1
LI		11-15-66	3000.	29.	1
N		11-15-66	7000.	29.	1
304SS		11-15-66	304.	29.	1
1/V		11-15-66	1.	0.	0
DY	164	11-15-66	66164.	0.	0
AU		11-15-66	79000.	0.	0
PA	233	11-15-66	91233.	29.	1
U	234	11-15-66	92234.	29.	1
NP	238	11-15-66	93238.	0.	0
CM	243	11-15-66	96243.	0.	0
CM	244	11-15-66	96244.	0.	0
U	233	4- 3-68	92233.	29.	1
U	235	4- 3-68	92235.	29.	1
U	238	4- 3-68	92238.	29.	1
PU	239	4- 3-68	94239.	29.	1
PU	240	4- 3-68	94240.	29.	1
PU	241	4- 3-68	94241.	29.	1
TH	232	4- 3-68	90232.	29.	1

Isotope/ Element		Date	First Ident	Second Ident	Number of Kernels
LU	175	11-15-66	71175.	0	0
LU	176	11-15-66	71176.	0.	0
EU		11-15-66	63000.	0.	0
CD		11-15-66	48000.	29.	1
HF		11-15-66	72000.	0	0
CR		11-15-66	24000.	29.	1
IN	115	11-15-66	49115.	0.	0
RH	103	11-15-66	45103.	0.	0
0	16	11-15-66	8000.	29.	1
0	16	2-15-67	8000.	30.	1
0	16	2- 6-67	8000.	31.	1
0	16	2-15-67	8000.	32.	1
0	16	2- 6-67	8000.	33.	1
0	16	2-15-67	8000.	34.	1
0	16	2-6-67	8000.	35.	1
0	16	12-11-67	8000.	36.	1
0	16	2- 6-67	8000.	37.	1
FE	56	11-15-66	26056.	29.	1
H	2	4- 3-68	1002.	1029.	2
H	2	4- 3-68	1002.	1030.	2
H	2	4- 3-68	1002.	1031.	2
H	2	4- 3-68	1002.	1032.	2
H	2	4- 3-68	1002.	1033.	2
H	2	4- 3-68	1002.	1034.	2
H	2	4- 3-68	1002.	1035.	2
H	2	4- 3-68	1002.	1036.	2
H	2	4- 3-68	1002.	1037.	2
H	1	11-15-66	1001.	1029.	2
H	1	2-15-67	1001.	1030.	2
H	1	2- 6-67	1001.	1031.	2
H	1	2-15-67	1001.	1032.	2
H	1	2- 6-67	1001.	1033.	2
H	1	2-15-67	1001.	1034.	2
H	1	2- 6-67	1001.	1035.	2
H	1	12-11-67	1001.	1036.	2
H	1	2- 6-67	1001.	1037.	2
H	1	4-10-69	1001.	1039.	2
H	1	4-10-69	1001.	1042.	2
H	1	4-10-69	1001.	1044.	2
H	1	4-10-69	1001.	1047.	2
H	1	4-10-69	1001.	1049.	2
H	1	4-10-69	1001.	1052.	2
H	1	4-10-69	1001.	1054.	2
H	1	4-10-69	1001.	1057.	2
H	2	4-10-69	1002.	1039.	2
H	2	4-10-69	1002.	1042.	2
H	2	4-10-69	1002.	1044,	2
H	2	4-10-69	1002.	1047.	2
H	2	4-10-69	1002.	1049.	2
H	2	4-10-69	1002.	1052.	2
H	2	4-10-69	1002.	1054.	2

Isotope/ Element	Date	First Ident	Second Ident	Number of Kernels
H 2	4-10-69	1002.	1057.	2
0 16	4-10-69	8000.	39.	1
0 16	4-10-69	8000.	42.	1
0 16	4-10-69	8000.	44.	1
0 16	4-10-69	8000.	47.	1
0 16	4-10-69	8000.	49.	1
0 16	4-10-69	8000.	52.	1
0 16	4-10-69	8000.	54.	1
0 16	4-10-69	8000.	57.	1
C 12	11-15-66	6012.	1082.	1
GD	7-16-69	64000.	29.	1
U233FPR	7-16-69	14233.	0.	0
U235FPR	7-16-69	14235.	0.	0
PU39FPR	7-16-69	14239.	0.	0
U235FP1	7-16-69	10235.	0.	0
U235FP2	7-16-69	11235.	0.	0
U235FP3	7-16-69	12235.	0.	0
U235FP4	7-16-69	13235.	0.	0
PU39FP1	7-16-69	10239.	0.	0
PU39FP2	7-16-69	11239.	0	0
PU39FP3	7-16-69	12239.	0	0
PU39FP4	7-16-69	13239.	0.	0
NP 237	7-17-69	93237.	0.	0
PU 238	7-17-69	94238.	0.	0
AM 241	7-17-69	95241.	0.	0
AM 243	7-17-69	95243.	0.	0
CM 242	7-17-69	96242.	0.	0
PU 236	7-17-69	94236.	0.	0
PU 242	7-17-69	94242.	29.	1
U 236	7-17-69	92236.	0.	0
AG 107	1-16-70	47107.	0.	0
AG 109	1-16-70	47109.	0.	0
H 1	2-09-70	1001.	2029.	2
XE 135	3-20-70	54135.	0.	0
SM 149	3-20-70	62149.	0.	0
SM 151	3-20-70	62151.	0.	0
GD 152	3-20-70	64152.	0.	0
GD 153	3-20-70	64153.	0.	0
GD 154	3-20-70	64154.	0.	0
GD 155	3-20-70	64155.	0.	0
GD 156	3-20-70	64156.	0.	0
GD 157	3-20-70	64157.	0.	0
GD 158	3-20-70	64158.	0.	0
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